REPORT

OF

THE COMMISSIONERS,

UNDER

AN ACT OF THE LEGISLATURE OF THIS STATE,

Passed February 26th, 1833,

RELATIVE

TO SUPPLYING THE CITY OF NEW-YORK

WITH

PURE AND WHOLESOME WATER.

NOVEMBER, 1833.

NEW-YORK:

PRINTED BY PETER VAN PELT, FRANKFORT-ST.

1833.

CROTON RIVER
RED MILLS
MAHOPACK LAKE
COLES MILL
West Branch of the Croton River
CARMEL
RESERVOIR
Middle Branch of the Croton River
MUSCOOT HILL
MUSCOOT BRIDGE
WOODS BRIDGE
SOMERSTOWN
OWENSVILLE
1st Junction
East Branch of the Croton River
RESERVOIR I
MECHANICSVILLE
GOLDINGS BRIDGE
RESERVOIR H
Deans Bridge
NEWCASTLE CORNERS
Muddy Brook
RESERVOIR G
RESERVOIR F
RESERVOIR E
BEDFORD
SODOM CORNERS
MILLTOWN

DOCUMENT NO. 36.

BOARD OF ALDERMEN,

NOVEMBER 12, 1833.

The following Report was presented by Alderman Palmer, received by him from the Commissioners, appointed pursuant to a law passed by the Legislature on the 26th February, 1833, *in relation to supplying the City of New-York with pure and wholesome Water. It was referred to the Committee on Fire and Water, with directions to have* 500 *copies printed, and to have the accompanying documents, consisting of maps of the Country through which the same will pass, and the Profiles showing the depression and elevation of the land, lithographed.*

J. MORTON, Clerk.

TO THE HONOURABLE THE COMMON COUNCIL

OF THE CITY OF NEW-YORK.

The Commissioners appointed pursuant to an act of the Legislature of this state, entitled, "an act for the appointment of Commissioners in relation to supplying the city of New-York with pure and wholesome water," passed 26th February, 1833, and in obedience to the directions of said act,

RESPECTFULLY REPORT,

That viewing the subject as the Commissioners do, of the utmost importance to the city and state of New-York, they have bestowed all that reflection and attention to its details which their limited time and capacity would admit.

In order that they might be enabled to ascertain with the greatest accuracy the practicability and expense of supplying the city of New-York with a sufficient quantity of pure and wholesome

water, both for present and future use, they engaged Canvas White and David B. Douglass, esquires, civil engineers, to make separate and distinct examinations of the Croton, Sawmill, and Bronx rivers, in the counties of Westchester and Putnam, together with their several tributaries ; and to furnish the Commissioners with a map and profile of the country, and their opinion of the quality of the water, the supply that might be depended on in all seasons, and the practicability of conveying it to the city at an elevation of sufficient height, that would preclude the use of machinery, and answer all the purposes contemplated.

The Engineers were also instructed to designate the best and most feasible route for conducting the water, the most fit and proper manner for constructing the conduits and reservoirs, the probable amount of damage that would be sustained by the proprietors of the water to be taken, and of the land it might be necessary to occupy in constructing the required conduits and reservoirs, together with the total amount of cost to the city for completing and putting into operation the whole project.

The Commissioners are sorry to state, however, that their anticipations that they would be enabled to present to the Common Council the separate opinion of two practical engineers, have not been realized, by the receipt of a report from Mr. White, who states, under date of the 30th October last, that his previous engagements on the Raritan and Delaware Canal, together with the frequent and heavy rains during the summer months, which caused an unexpected flooding of the works, has demanded so much of his unremitted attention as to prevent him from fulfilling his contract with the Commissioners. A statement of the causes, which prevented Mr. White from complying with his engagements, has been furnished the Commissioners, and is annexed to this report, to which they beg leave to refer.

It is, nevertheless, with great pleasure that the Commissioners are enabled to present to the Common Council a full and ample report from Mr. Douglass, with a map and profile of the country in which the rivers, lakes, ponds, and springs are situated, capable of supplying this city with an abundance of as pure and wholesome water as any country can boast of.

The following abridgment of the report, alluded to, will present a brief view of the conclusions arrived at by the Engineer.

Two routes are proposed for bringing the waters of the Croton,

and its tributaries, to the city of New-York, which are termed, by the Engineer, *The Inland or Sawmill river Route*, and *The Hudson river Route.*

FIRST, THE INLAND OR SAWMILL RIVER ROUTE.

It is proposed to form a basin, or confluent reservoir, at a point near Mechanicsville, in the town of Bedford, county of Westchester. The position chosen for this reservoir is 268 feet above the tide-waters of the Hudson, and forms a natural basin of solid rock, requiring very little embankment or artificial work to complete its structure.

To this reservoir the following streams may be brought by means of iron pipes of large size. First, the Muscoot river, at the distance of three and one-eight of a mile, which will afford a supply of 3,628,800 gallons per diem. Second the Cross river, at three miles distance, and giving 9,124,400 gallons per day. Third, the Beaver Dam and Broad Brook streams, producing 4,963,480 gallons per diem. Fourth, the main Croton, including the east, west, and middle branches, which gives 12,695,480 gallons per day, making a total of 30,460,160 gallons every twenty-four hours, that will enter the confluent reservoir, if permitted; and, if we add to this the quantity produced by the river Cisco, we have 32,503,760 gallons running water for daily use, if required.

These several streams were gauged on the 4th, 5th, and 6th of September last, at a time when no rain, of a day's continuance, had occurred for about two months; and the opinion of the inhabitants was, that the streams were as low as they had ever been, except at a remarkable drought in 1816. To meet a like occurrence, should it again happen, it is proposed to deduct one-fifth from the foregoing results, which will reduce the quantity flowing on to the city to 26,002,008 gallons per day.

From the confluent reservoir the water is to be carried in an aqueduct of masonry, the construction of which is particularly described in the report of the Engineer, to the head-waters of the Sawmill river, which will require a deep cutting of about three miles, averaging 38 feet in depth and 55 feet at the dividing ridge. This is considered the principal difficulty in the location of this route.

Twelve miles from the confluent reservoir the Engineer points out a favourable position, of 258 feet above tide, for a storing

reservoir, should it be required or deemed at all necessary. For the next fifteen miles the ground goes off at a gentle slope, requiring no cutting or filling to any extent, or extra work of any kind, except in one or two instances.

The entrance to the valley of Tibbit's brook requires a cut through the dividing ridge of 12 chains, or 792 feet in length, and 22 feet deep on an average, chiefly in rock; or it may be tunnelled, which will shorten the distance 50 or 60 feet. At this position another favourable place is proposed, 147½ feet above tide, for a storing reservoir, if required.

From this the route passes on the Harlem river, without any material obstruction to the work, either by deep cutting or high embankments. The river is to be crossed by an aqueduct bridge of 18 chains, or 1188 feet in length, and consisting of nine plain semicircular arches; the height, to the water-line of the aqueduct, will be 126 feet.

On the aqueduct crossing the bridge, and entering the island of New-York, it proceeds to a receiving reservoir, located, by the profile accompanying this report, between the Ninth and Tenth Avenues and One hundred and thirty-third and One hundred and thirty-seventh-streets, at a height of about 123 feet above tide; and from thence, by conduit pipes, to reservoirs, termed by the Engineer, equalizing reservoirs; one on One hundred and fifth-street, between the Eighth and Ninth Avenues, and the other on Sixty-ninth-street, east of the Eighth Avenue; and finally, to a distributing reservoir, at the intersection of Thirty-eighth-street and the Fifth Avenue, three miles from the City Hall. The distributing reservoir is calculated to contain between fifty and sixty millions of gallons, and the water to stand in it at the depth of 20 feet, and 117 feet above the tide. The distance from the confluence reservoir to the receiving reservoir, at Manhattanville, is 37 miles 52 chains, and from that to the distributing reservoir, on Thirty-eighth-street, is five and a half miles, making the whole distance of this route about 43 miles from the confluent reservoir, at Mechanicsville, to the distributing reservoir, in the city of New-York.

The cost of the works is estimated at the sums following:

For the conduits to the confluence reservoir, from the Muscoot, Cross river, and Beaver dam,	$761,000	
Indemnity for water rights,	43,500	
Contingencies,	50,000	
Total expenses of the water of lower Croton,		$ 854,500
Upper Croton and branches, including dams, conduits, &c.	$1,155,000	
Indemnity for water rights,	57,000	
Contingencies,	65,000	
		1,277,000
Total for bringing these waters to confluent reservoirs,		2,131,500
Expense of the first twelve miles from the confluent reservoir, to and including the deep cutting at Sawmill river, viz.— For cutting and filling nine and a half miles, including culverts, &c.	$61,420	
Excavating two and a half miles of tunnel, one quarter rock,	114,000	
Constructing confluent reservoir, channel way, &c.	558,000	
		733,420
Expense of the remaining 31 miles, viz.— For cutting and filling from Sawmill river to the receiving reservoir,	$191,000	
For Harlem and two small aqueducts, Tibbit's dam, and several culverts,	576,000	
Channel of aqueduct way complete,	1,020,000	
Receiving, equalizing and distributing reservoirs,	200,000	
Iron main at $100,000 per mile,	550,000	
Contingencies,	325,067	
Damage to land and water rights,	100,000	
		2,962,317
Total cost of bringing the water to the city,		$5,827,237

It may be proper to observe here, that the quantity of water may be reduced or increased at pleasure, by using or not, as the case

may be, any or all of the streams leading to the confluent reservoir, as shall be deemed necessary to furnish a full supply. Thus, if we exclude the water of the upper Croton branches, viz. the west, middle, and eastern branches, which will require to be brought in iron conduits for about fourteen miles, we shall still have a daily supply of about sixteen million of gallons, and a reduction in the expense of $1,277,000; leaving the actual cost of the project at $4,550,237.

SECOND, THE HUDSON RIVER ROUTE.

It is proposed, on this route, to build a dam across the main Croton, about one mile below Mechanicsville, and a mile and a quarter below the confluent reservoir. The height of the fountain-head thus formed, will be about 175 feet above tide, and the quantity of running water which will come to this reservoir, including the discharge from the Muscoot river, will be 44,120,924 gallons daily.

The location of this route, until it penetrates the valley of the Sawmill, is carried along the hill side of the Hudson and Croton rivers; the line follows the north bank of the Croton to Garritson's mill, when it crosses the river or an aqueduct of 85 feet span, to the south bank, where an arch must be thrown over the road in order to admit the passage of travellers. A number of culverts must be built, and several excavations made, of 20 to 23 feet in depth, on this part of the line.

Near the mouth of the Croton, a work of considerable magnitude occurs, where the ground will have to be excavated to the depth of 35 feet at the summit. After leaving the valley of the Croton, near Sing-Sing village, another deep cutting occurs, of 36 feet at the summit; and in crossing the chasm, or gap, at Sing-Sing hill, a culvert of 60 feet span will be necessary. The route then proceeds nearly on a line with the turnpike road, without any material excavations or embankments, for 19 miles, from the Croton reservoir to Sleepy-Hollow. In crossing this hollow, an aqueduct of five arches, of 70 feet span, and 500 feet in length including the wings, and 60 feet in height to the water line, will be necessary.

Two miles below this, at Tarrytown, a cut of 15 feet, and about two miles further on, another, of 26 feet, will be required. Several heavy culverts must be constructed, one of which, in the vicinity of Greenburg landing, must have a span of 20 feet. Here the

route leaves the line of the turnpike road and inclines east, towards the valley of the Sawmill river. In order to enter this valley, a deep cutting will be necessary, of 45 chains, or 2970 feet in length, and averaging 37 feet in depth, chiefly rock. After entering the valley, the Sawmill river has to be crossed, which will require an aqueduct, of three arches with 60 feet span, making the length, including wings, 250 feet, and the height above the river, 36 feet.

The Hudson river route, and the Sawmill or interior route, now take the same line to the city. The former, however, is considerably lower in its grade than the latter, and consequently the magnitude of its works will be increased. The Harlem river is to be crossed by both routes, in the same manner, to the receiving reservoir, between the Ninth and Tenth Avenues and 133d and 137th streets, on the island of New-York. The distance from the dam, on the Croton river, to the distributing reservoir, at the intersection of 38th street, is nearly 47 miles.

The expense of constructing the Hudson river line will be as follows:

For cutting and filling, including the dam of the Croton, and small culverts on the whole line,	$674,651
Eight aqueducts, including the Harlem river, Sawmill river and Sleepy-Hollow,	812,000
Channel way for aqueduct, or open conduit, 35½ miles in soil, and residue in rock,	1,985,800
Reservoirs and mains on N. York island,	750,000
Damage to land and water rights,	73,500
Contingencies,	422,245
Total cost of Hudson river route,	$4,718,197

As the Corporation are in possession of a survey and map of the country, embracing the Bronx river and its sources, the Commissioners have not deemed it important to spend much time in the examination of that river, with the object of supplying the city with its waters; particularly, as the running water to be obtained, it is believed, would barely be sufficient for present purposes, without reference to the future; and their time being limited to the month of November, when, by the act under which they are appointed, the report to the Common Council is directed to be made, and the

examination to cease, they have deemed it more profitable to lend their whole attention to a source of supply, where the adequate quantity may be obtained at all seasons, both for the future as well as for the present.

Some attention, however, has been given to the subject, as may be seen by the report of the Engineer. In order to test the correctness of an opinion, that the Harlem river possessed the requisite power to raise the water to a sufficient elevation on New-York island, a calculation has been entered into, the result of which is, that the whole power of the river would only raise to the requisite height, 4,939,000 gallons in 24 hours, being about two millions less than the present wants.

By a reference to the map, it will be seen, that a line has been run, commencing at Popham's factory on the Bronx river, where a head of 142 feet above tide was gained; from whence the line continues down the west side of the river, taking the same ground, from the vicinity of Fordham's church, as that occupied by the routes from the Croton; the ground is by no means unfavourable, but, in crossing, an aqueduct of 740 feet, at an elevation of 57 feet, will be required. The whole distance from the factory dam to the distributing reservoir, is 21 miles.

The Engineer made a gauge of the outlet of Rye ponds, on the 15th and 20th of August and 5th of September, and found the discharge to be only 950,400 gallons daily. The running waters of the river were gauged on the 4th and 5th of September, and produced 4,331,880 gallons every 24 hours. Allowing one fifth to meet extraordinary drought, there remains 3,465,504 gallons. By damming the ponds, an additional supply may be obtained of 2,286,900 gallons, making a total of 5,752,404 gallons, as the quantity that can with any safety be relied on from that source, and which is less than the present wants, by about one million of gallons. A small addition may be obtained from Byram river, but in effecting it, a resort must be made to the territory and waters of another state, which it is presumed would not be attempted, unless by the authority of that state.

The Commissioners having understood, that a proposition from the Manhattan Company, to dispose of their works to the Corporation, is now under the consideration of the Common Council, and observing by a printed circular from that Company, that they have 25 miles of pipes now laid down in this city; and having also been

informed, that the Corporation have about ten and a half miles of pipe, extending in different directions from their reservoir on Thirteenth-street, that they have not deemed it necessary under these circumstances, to enter into a calculation of the cost of the pipes, that may be required to distribute the water in the different parts of the city. The estimates which have been made, however, for bringing the water to the distributing reservoir, are full and large, and intended to exceed, rather than fall short of the cost. The Commissioners think, therefore, that these estimates may be relied on, as amply sufficient, to complete a work that will be a lasting blessing to the present and future inhabitants of this city, and an honour to those who may be instrumental in carrying it into effect.

For a more particular and detailed description of the survey, and other important information on the subject, the Commissioners beg leave to refer to the able and lucid report of the Engineer, hereunto annexed.

The routes which are designated by the report of the Engineer, for bringing the waters of the Croton to the city, differ so little in expense or feasibility, that the Commissioners have not deemed it necessary to make a selection of one in preference to the other, as a further examination, connected with facts and circumstances which may hereafter come to view, will better enable those to decide, who may be selected to carry the project into effect, than they are.

That the Commissioners might be enabled to form as correct an opinion of the subject generally, as the nature of the case and their other engagements would admit, they have personally explored the routes proposed by the Engineer, and have made frequent examinations of the situation, quality, and apparent quantity of the water to be taken, and by conversation with intelligent individuals in the vicinity of these waters, or who were acquainted with the country and its localities, they have arrived at the conclusion, than an adequate supply of good and wholesome water is not to be obtained from any source, with as much certainty of success, with greater convenience, or with less expense, than that recommended by the report of the Engineer.

The construction of these works will require several years to complete them, and the supply, therefore, must be estimated to meet the wants of the then population, which it is presumed will not be less than 300,000. On estimating the quantity that may be

required for all purposes, the Commissioners have endeavoured to ascertain the number of gallons distributed in other large cities, such as London, Philadelphia, and Edinburgh.

It appears from an investigation, by order of the British Government, into the concerns of the London Water Companies, that the quantity of water furnished the city was equal to 162 gallons for each house per diem, or 27 gallons to each inhabitant, counting six persons to each house.

The city of Philadelphia, as shown by a report of the watering committee for 1832, supplies 13,806 houses, factories, &c. with about two million of gallons per day, equal to 146 gallons to each establishment, or about 24 gallons for every inhabitant, allowing six persons to a house.

The city of Edinburgh and Leith distributes about 15 gallons to each inhabitant, estimating 130,000 persons who use the water, or 1,950,000 gallons every twenty-four hours. These works may be increased, so as to deliver 2,661,120 gallons per day, equal to twenty and a half gallons to each person.

The mean rate of these several quantities of 27, 24, and 15, is 22; and the Commissioners have adopted 22 gallons for each inhabitant of the city of New-York, as the quantity required for every purpose, which will make it necessary that 6,600,000 gallons should be delivered at the distributing reservoir every 24 hours. The Commissioners have shown, however, that five or six times that quantity may be obtained, and brought to the city, if required.

Every city of note, whether in our own country or in Europe, has found it indispensable, so soon as the population became densely settled, and the streets paved and compactly improved, to look for a supply of water from distant and remote sources.

The magnificent works of the Romans, erected for the purpose of conveying water to that city, are spoken of with admiration by those who have examined what still remains of them. We are told that the water was brought from sources at the distance of thirty, forty, sixty, and in some instances, of one hundred miles; that there were twenty aqueducts through which the water was conveyed, and the supply was equal to 40,000,000 of gallons daily. To effect this object, mountains were levelled, rocks excavated, in one instance of a mile in length, and valleys were filled up. The aqueducts of Nismes, and Metz in France, and of Constantinople in Turkey, also owe their construction to the Romans.

In more modern times, reference may be had to the cities of London, Paris, Versailles, and Edinburgh in Europe, and Philadelphia and several other cities of less note in our own country.

Most of these cities possessed local advantages for a supply of water, far greater than the city of New-York; for in addition to their wells, our only resource, the waters of the rivers on which they were situated, were fresh, while that which surrounds this city is salt and unfit for the use of man.

The city of London, until it became densely settled, drew its supply of water from wells and several small streams in the vicinity, and when the well water became hard and unfit for ordinary use, and the streams obstructed by buildings, resort was had to the water of the river Thames, by means of machinery; but this was found so liable to become turbid and foul, that pure water became a desirable object with the inhabitants, and in 1608 the present works of the new river were commenced, and finally completed in 1613.

The people of Rome were contented with the water of the river Tiber and the wells in that city, for a length of years after its first settlement; but when the buildings and population became dense, they also found it necessary to resort to remote places for a supply of pure water, by the means of aqueducts.

The same causes which operated in these and other cities, and which induced a resort to distant sources for a supply of good water, are now operating in the city of New-York with increasing force—viz. an almost total deterioration of the water obtained from the wells and pumps, in all that part of the city closely built upon and densely populated.

The water procured from a large portion of the wells of this city, where the population has become dense, is unfit for ordinary use, and very deficient in supply; and the well belonging to the Manhattan Company in Reed-street, which supplies a portion of the inhabitants with water for drink and culinary purposes, although it is said to be capable of yielding more than 1,000,000 gallons in twenty-four hours, is nevertheless of the same bad character with the other wells in the thickly populated parts of the city, and is so impregnated with foreign matters, that the use of it, in the opinion of the Commissioners, must be more or less injurious to the health of those who partake of it.

In 1831, a communication was presented to the Common Council of the city of New-York, by a committee of the "Lyceum of

Natural History," answering certain queries proposed to that Institution on the practicability of supplying the city with good water within its own limits. In the communication alluded to, the Committee enter into an examination of the sources, the quantity, and the purity of the water on the island of New-York, and arrive at the following conclusions:

First, that the water obtained from the wells in this city is derived wholly and exclusively from the atmosphere, either in the shape of rain, hail, or snow; that this is first absorbed by the sand or earth, through which it descends until it reaches the rock on which the island rests, or until it saturates the earth and can make no further progress.

Second, that by numerous observations the annual fall of water, on an average, is calculated at about thirty-six inches; but, that the available amount cannot be accurately estimated, as allowance must be made for the evaporation and the quantity carried off over the paved streets, and other outlets to the river.

Thirdly, from analyses of a number of the well and pump waters, in different sections of the city, by George Chilton, esquire, chemist, it has been ascertained, that the water of one of the wells contained ten grains of foreign matter in a pint, or eighty grains to the gallon; another, seven grains to the pint, or fifty-six to the gallon; a third, thirty-six to the gallon; and a fourth, about thirty-three to the gallon. These gentlemen state as their unanimous opinion, "that no adequate supply of good and wholesome water can be obtained on this island, for the wants of a large and rapidly increasing city like New-York."

There are wells, however, in the thinly settled parts of the island from which good water is still obtained; but from the fact, within the recollection of hundreds, that but a few years back the wells now producing bad water then produced good, the Commissioners conclude, that the water obtained in the northern parts of our city, when that section shall become densely populated, will share the same fate as that in the south, where it has undergone a change from good to bad.

An opinion is entertained by many of our citizens, however, that water of a good quality, and in sufficient quantity, may be obtained in any part of the city of New-York, by deep excavating or boring of the rock on which this island rests.

The Commissioners have endeavoured to obtain information on

this subject, and, with that object, they have inspected such of the wells as have produced good water, in considerable quantity, by deep excavation or boring in the rock ; and to the same end, they have been furnished by Mr. Levi Disbrow, who holds a patent for his improved instruments used in penetrating or boring rock, with a detailed statement of the whole of his operations in boring for water on the island of New-York.

From this document it appears, that he has operated in *twenty-three* different sections of the city, and has, except in a few instances, been successful in producing good water. In *seventeen* cases he terminated at, or before reaching the rock, and penetrated the earth from *sixty to one hundred and thirty feet* below the surface ; and, in six cases, he penetrated the rock from *one hundred and twenty to five hundred feet.*

The principal and most successful operations of Mr. Disbrow are, the deep boring for the Manhattan Company at the corner of Broadway and Bleecker-street, and for Mr. G. Richards' distillery at the corner of Factory and Perry-streets. He has also made a boring at Holt's hotel, corner of Pearl and Fulton-streets, of one hundred and thirty feet in the earth and five hundred in the rock, or six hundred and thirty feet below the surface. The success of this operation, however, was not ascertained when this report was written, except that it yielded brackish water.

The next operation worthy of note, though not effected by Mr. Disbrow, is the well sunk by the Corporation of this city, at Thirteenth-street. This well is 17 feet in diameter, and 113 feet in depth, with three horizontal excavations of four feet in width and six in height, and extending from the bottom of the well, in the rock, two of them seventy-five and one of them one hundred and ten feet in length.

This well produces about 21,000 gallons of water in twenty-four hours. The water, however, on applying the usual test with soap, proved hard, no foam being formed on its surface, and to the taste it appeared strongly impregnated with some mineral substance, which unfitted it for drink or culinary purposes.* The Commissioners were, nevertheless, assured by several members of the Corporation, that before excavating the horizontal openings the

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* See note on the next page.

water was as pure and soft as that which descends from the clouds, and that the change in its quality was entirely owing to that operation.

The well at Mr. Richards' distillery is sunk two hundred feet through the earth and rock, and yields about the same quantity of water as the well sunk by the Corporation.

The well sunk by the Manhattan Company the Commissioners consider a very successful operation. It is 442 feet in depth, 42 feet from the surface to the rock, and 400 feet in the rock. The water did not appear to be perfectly soft on testing it with soap,* but may, with much propriety, be pronounced good and wholesome; and why it has not been distributed to the citizens by the Company, instead of the disagreeable and unwholesome article drawn from their well in Reed-street, is to the Commissioners unaccountable. It does not follow, however, because this boring has succeeded in bringing up a large supply of good water, that all other attempts will be successful. That many of them will fail in quantity, as

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* Since writing the foregoing Report, the Commissioners have received the following analysis of the water taken from the well in Bleecker-street, and from the Corporation well in Thirteenth-street, a quantity of each having been furnished Mr. Chilton for the purpose :

BLEECKER-STREET WATER.

By the application of tests, this water contains sulphates, muriates, carbonates, iron, and vegetable extract, in considerable quantity.

One quart yielded, by evaporation, 20 grains of solid matter, three-fifths of which were soluble in water containing sulphate and muriate of soda and magnesia, with a little sulphate of lime; the other two-fifths consisted of carbonate of lime, carbonate of magnesia, sulphate of lime, iron, and extract.

CORPORATION WELL.

This water contains nearly the same ingredients as were found in the Bleecker-street water, but less in quantity. One quart left, by evaporation, 14.1 grains.

Note. If the Commissioners think it necessary, these waters can be examined with greater minuteness and precision, as we can command any quantity, they being accessible and on the spot.

(Signed)

GEORGE CHILTON.

November 11th, 1833.

well as quality, is evident, we think, from the results of the Corporation well. Before the excavations in the horizontal openings in that well, the water was pure and soft; but by extending one of these excavations only thirty-five feet further in the rock than the others, it became hard and unfit for ordinary use; and there is no good reason, in the opinion of the Commissioners, why a boring thirty or forty feet distant from the well in Bleecker-street may not produce water equally unfit for use with the well at Thirteenth-street.

The well at Bleecker-street is said to be capable of yielding upwards of 120,000 gallons in twenty-four hours, while the well at Thirteenth-street only yields about 21,000 gallons in the same space of time. The Bleecker-street well is but seven inches in diameter, while the Thirteenth-street well is 17 feet in diameter, besides three excavations of four feet wide and six feet high, two of them seventy-five in length and one 110 feet in length. The great space of rock which has been penetrated in excavating the Thirteenth-street well, compared with that at Bleecker-street, and the disparity in the quantity of water furnished by the former, when compared with the latter, shows conclusively that the same success, which has resulted from the boring at Bleecker-street, cannot be expected to follow every similar operation; otherwise the supply at Thirteenth-street ought to have been immeasurably greater, instead of so much less, than that at Bleecker-street.

The well sunk by the Corporation at Thirteenth-street, although a very useful project, has been a very expensive one to the city, having cost, including the land, $57,972 38 cents. The Commissioners have no data by which to estimate the cost of the Manhattan well, if put in a situation to distribute the water, with *engine*, *reservoir*, &c., similar to the well in Thirteenth-street; but they have no reason to think it will be less than that belonging to the Corporation. Nor can the Commissioners bring their minds to the conclusion, after an impartial view of the various experiments which have been made, and the information they have been enabled to collect on the subject, that the project of boring for water will be more successful on a general scale, either in cost or supply, than that of the well at Thirteenth-street.

The Commissioners estimate the present population of this city at about 250,000; and as a large portion of the 12th ward is under culture, and will not require an immediate supply of water, we deduct

12,000 as the probable population, leaving the population of the 14 lower wards at 238,000, or for each ward about 17,000 inhabitants. It will require, therefore, allowing twenty-two gallons for each person, 374,000 gallons for the daily consumption of each ward; and, consequently, three such wells as that on Bleecker-street to supply it, or forty-two in all, with their steam engines in constant operation.

In a financial point of view, taking the Corporation well as a data, it will appear, that the annual expense to the city, by the project of deep boring for water, will be much greater than for bringing it from a distant source.

It has been stated, that the Corporation well cost $57,972, and that it will require 42 wells, yielding 125,000 gallons daily, to supply the present population.

42 wells, including the land, engine, reservoir, &c. will amount to		$2,518,825
The interest on this sum annually, at 5 per cent. will amount to	$125,941	

The annual expense of working an engine of 12-horse power, night and day, is estimated as follows:

42 bushels of coal per day, at 21 cents, for 365 days, is	3,219 30
2 engineers and 2 assistants, at 6 dollars per day,	2,119 00
Oil, tallow, &c. at 14 cents per day,	51 10
Wear and tear of machinery, at 30 cents per day,	109 50
Annual expense of one engine,	$5,569 90

The annual expense of 42 engines will be	233,935
Add the interest on capital, as above,	125,941
Total annual expense for raising water from wells,	$359,876

Assuming the sum of five millions of dollars as the cost of bringing the Croton waters to the city, and the interest on this sum at 5 per cent. will amount to $250,000, which is $109,876 less, annually, than what it will cost to raise the water by machinery, if the data we have assumed be correct.

Now, if we were satisfied (which we are not) that by the operation of boring, a sufficient supply of water could be obtained, in each of the wards, to employ these *forty-two* steam engines in fill-

ing as many reservoirs with good water, and that the expense would not exceed the bringing it from a distance, a strong objection would still arise to placing *forty-two* steam engines in the densely settled parts of the city, to annoy and disturb a neighbourhood with the unceasing noise and clatter of the machinery, the constant smoke of the furnaces and the incessant discharge of steam; thus depreciating the value of property for a distance around, and driving from their vicinity every citizen whose means would permit him to seek for more peaceful and comfortable quarters. But when we take into consideration the uncertainty of a supply, even equal to that now obtained from these sources, the difficulty and expense of elevating the water to a sufficient height, and the reasonable ground we have to fear that, whenever the vicinity of these wells shall be densely settled, the water will deteriorate and become unfit for use, there would seem to be sufficient reason to induce the Corporation and citizens to discard all reliance for a sufficient supply of good water, on the sources within the limits of this city, and to look to a distant source, abundant in its nature, and not subject to doubt as to its quality, quantity, or practicability of introduction, and at such an elevation as shall exclude the necessity of using machinery.

The subject of supplying the city of New-York with water is, by no means, a new project or of recent date, for, as early as 1774, when the population of the city did not exceed twenty-two thousand inhabitants, works were commenced on the then high ground to the northwest of the Collect Pond then in existence, but now filled up and converted into building lots. Christopher Collis was the engineer to these works, and, under the direction of a committee of the Common Council, he constructed a spacious reservoir on the east line of Broadway, between, what is now known as, Pearl and White-streets, and sunk a well of large dimensions in the vicinity of the Collect. For the purpose of defraying the expense of the work, the Corporation issued a paper money, amounting to *two thousand five hundred pounds*, under the denomination of water-works money, and bonds were executed in favour of certain individuals for land and materials to the amount of *eight thousand eight hundred and fifty pounds* more. The war of the revolution, however, which commenced in 1775, and the consequent occupation of this city by the British troops, was the cause of the abandonment of the work in its unfinished state.

In 1798 the Common Council appointed a committee to investigate the subject of supplying the city with good water, who reported as their opinion, that a supply might be obtained from the river Bronx, and submitted a memoir, drawn up by Dr. Joseph Brown, recommending these waters.

In 1799 the Common Council employed William Weston, a civil engineer, to examine the river Bronx, relative to bringing its waters to the city, and to report his opinion to the Corporation, with the requisite plans and estimates, as soon as practicable.

In March, 1799, Mr. Weston made his report. He seems to hold the opinion, that the Bronx will give a supply, but furnishes no gauge of the river, further than to calculate the quantity contained in the Rye ponds, its principal source; nor does he furnish any estimate of the expense.

We find nothing on the minutes of the Common Council on the subject, until 1822, owing probably to the incorporation of the Manhattan Company, by act of the Legislature, passed the second of April, 1799.

The avowed object of this Company was, to supply the city with pure and wholesome water; but, instead of looking to a foreign source for a supply, as their charter indicated, they have contented themselves with erecting their present works on Chamber and Reed streets, and instead of a supply of good and wholesome water, they have distributed, and continue to distribute, an article, which according to an analysis made in 1831, by George Chilton, esquire, contains one hundred and twenty-five grains of foreign matter in every gallon.

In 1822 the subject was again brought to the consideration of the Common Council, by the Mayor, and a committee was appointed, to which it was referred. In the month of March of that year, this committee reported, that they had made a personal examination of the Bronx river, and of the lakes which form its principal source, and recommend the appointment of a civil engineer to make surveys, and furnish profiles, maps and estimates of the cost.

The Engineer employed was Canvas White, esquire, who did not report to the Corporation until 1824. In this report, Mr. White proposes taking the water of the Bronx from the Westchester Cotton Factory pond. He thinks that the natural flow of the river, in the driest season, will furnish 3,000,000 gallons per day, and by raising a dam of six feet to the upper Rye pond, and low-

ering the outlet two feet, 3,600,000 gallons more, per day, may be obtained, and thus a daily supply of 6,600,000 gallons can be brought to the city every twenty-four hours. The cost of bringing the water to a reservoir near the Park, is estimated at $1,949,542.

Here the subject rested again until 1825, when the Legislature incorporated a company, by the name of the New-York Water Works Company, with authority to supply the city with pure water. Canvas White, esquire, was also appointed Engineer to this Company, and in his report to the Directors, he recommends taking the waters of the Bronx at Underhill's bridge; estimates that 9,100,000 gallons of water may be delivered in the city, daily, and that the whole expense will not exceed $1,450,000.

The charter of this Company proved so defective in practice, that they were unable to proceed under it, and they accordingly applied to the Legislature in 1826 for an amendment, authorizing the Company to take such of the waters, land and materials, by appraisement of indifferent persons, as might be required for the work. In this application, however, they were defeated, by the opposition of the Sharon Canal Company, incorporated in 1823, who claimed under their charter all the water on the route of their canal. The Water Works Company was accordingly dissolved in 1827.

In 1831, a committee of the Board of Aldermen reported in favour of applying to the Legislature for an act, granting power to the Common Council to raise money by loan, for the purpose of introducing a supply of pure water to the city. The act was trans mitted to the Legislature, but did not pass into a law.

In 1832, De Witt Clinton, esquire, Civil Engineer, was employed by the Common Council to examine the route to Croton river, and such other sources in that vicinity, from which an inexhaustible supply of pure water may be obtained; to report the best plan of crossing the Harlem river, conducting the water to the city, and the expense of the whole project.

In December, 1832, Mr. Clinton reported in favour of taking the waters of the Croton at Pine's bridge, which he states to be 183 feet above the level of the Hudson; to conduct the water in an open aqueduct following the line of the Croton and Hudson rivers, and cross Harlem river on an arch of 138 feet high, and one thousand feet in length. The whole cost he estimates at $2,500,000.

It does not appear, however, that any levels were run, or survey

made by Mr. Clinton, of the route he recommends; but, that he depended on the information of others, together with his personal observation, for the subject matter of his report.

In 1833, the Common Council petitioned for the act, under the authority of which this report is made, and which became a law of this state, on the 26th of February, 1833.

The foregoing is but a brief outline of the various attempts which have been made to consummate this interesting object: and the reason for introducing them in this report, is, mainly to show, that from a very remote period to the present time, the project has been considered indispensable to the welfare of the inhabitants of this city, and that, as the improvements are extended, and the population increased, in the same ratio will the necessity and importance of the measure increase in magnitude.

So much has been said and written by learned and scientific men, on the utility and necessity of a copious supply of pure and wholesome water, for the use of this large and growing metropolis, that it may be deemed futile in the Commissioners to attempt any additional observations on a matter, so ably elucidated by those who have gone before them. They must claim the privilege, how ever, of making a few brief remarks.

The necessity of a supply of this indispensable element of consumption, appears now to be generally admitted, both as conducive to the health and prosperity of the city, as well as to the immediate comfort of its inhabitants, and the numerous visitants on business or for other purposes. The daily use of a fluid, containing a portion of mineral substance, which we are assured by eminent practitioners of medicine, is more or less injurious to health, imperceptibly undermining the whole animal system, and producing disease, which either shortens life, or makes it miserable, is a matter of too much importance, not to have attracted the attention of the visitors, as well as the residents of this city.

It is a fact also, which the Commissioners presume will not be disputed, that the whole state is deeply interested in the health and prosperity of this city, both as a market for its produce, and a mart at which the merchandise of every quarter of the globe may be obtained. One season of epidemic disease, therefore, by which the inhabitants of other parts of the state shall be deprived of this market, whether it be for the sale of the agricultural products of the country, or for a supply of domestic and foreign articles of use

and consumption, would be of more real injury, in the aggregate, than the expense of carrying the project, of supplying this city with pure and wholesome water, into effect, will cost. No facility, therefore, which the Legislature can consistently grant in furtherance of this necessary project, ought to be withheld.

In a domestic point of view, and relative to the general health of the city, in which every man, woman or child is interested, as well those who are still blessed with a supply of good water in their vicinity as those who are not, the subject is of the first importance. In this point of view, the benefits from a sufficient and copious supply of water, for the purpose of washing the streets, gutters, and sewers, are incalculable. By bringing the water to the city at a proper elevation, bathing establishments may be supplied on moderate terms, as well in private houses, as in those of public resort. Fountains may be opened in the public squares at a trifling expense, improving the atmosphere, and thus promoting the general health and comfort of all. The occurrence of pestilence may be prevented, or at least very much mitigated in its severity ; the prosperity of the city advanced; the interest of those who depend on the metropolis of the state as a market for their produce, promoted, and the comfort and happiness of posterity secured.

For the extinguishment of fires, the benefits of an adequate supply of water must be self-evident, not only in preventing the destruction of a vast amount of property, but in the preservation of the lives as well as the health of our firemen and others, and the total ruin in many instances of those who are the subjects of the calamity. The advantages which have resulted from the partial supply of water from the Corporation well at Thirteenth-street, for this purpose, has been such as to warrant the belief, should a sufficient supply of water be procured and conducted through all the streets of the city, that several hundred thousand dollars would be annually saved by the operation.

In addition to all these benefits, with many others not enumerated, there would be saved to the owners of real estate the expense of building cisterns for the reception of rain water, and the digging of wells for the production of pump water, together with a large reduction of the premium now paid for insuring against loss by fire.

The utility of the measure being acknowledged, as the Commissioners have reason to believe it is, by a large majority of the citizens, the only questions of importance which can arise on the

subject, are, first, the source from which the water is to be brought; second, the manner of bringing it; and third, the difficulties to be encountered, and the expense of the project.

With the information in the possession of the Corporation, should they decide to carry the project into effect, the first and second consideration may be safely entrusted to the judgment of those who shall be selected to superintend and direct the operations. The difficulties to be encountered, are much less, in the opinion of the Commissioners, than those which have been overcome, both in this country and Europe. The deep cuttings and embankments on the Erie canal, are far greater than any thing which occurs on the line by which it is proposed to bring the water to this city; and were it necessary, numerous internal improvements might be referred to, in various parts of the United States, both on the canals and rail-roads, where greater obstacles have been overcome, than any we have to contend with. In Europe, instances are in abundance, where insurmountable difficulties, in appearance, were overcome. In the construction of New River Water Works, at London, the water is brought by a winding course forty-two miles, crosses several valleys of considerable extent, and in one instance runs in a subterraneous channel for 600 feet beneath a street of the city. The original shares in this company was one hundred pounds each; they are now said to be worth one thousand pounds each. For the purpose of introducing good water into the city of Edinburgh, a great bank was constructed across a valley, 450 feet at the base, and 120 feet in height, which increased the cost of the work at least one third. The aqueduct by which the water is conveyed to the city, is, at one point, carried along an artificial embankment 40 feet above the natural surface of the earth. In another, a tunnel was necessary 80 feet below the surface, and in another, the solid rock was excavated, forming a subterraneous passage of 700 feet in length. Now, if this city, with its population of 150 thousand, was willing to encounter the difficulties above noted, with a view of providing for a supply of pure water, how much more ought the city of New-York, with its 250,000 inhabitants, be willing to encounter the few obstacles which appear in the way of consummating a like object?

As to the cost, necessarily large, owing to the situation and construction of the island on which the city is built, and the distance from which the water is to be brought, there cannot

be a doubt, in the opinion of the Commissioners, but that the operation will prove a saving concern, if properly and judiciously conducted, and eventually, when the population of the city shall have reached its maximum, result in great profit to the proprietors.

This state has the honour of being pioneer in the great improvements of intercourse by canals and rail roads, and the project under consideration, although not of such general interest as the others, is nevertheless, in some points of view, equally important ; and, if effected, will be creditable to the state as well as to the city. In this respect, therefore, the subject recommends itself to the favourable consideration both of the Corporation and of the Legislature.

An accurate map has been drawn of the country, in which the head-waters of the Croton, Sawmill, Bronx, and Byram rivers, are situated, designating the lines which have been run by the Engineer, and the proposed routes for conducting the water to the city ; also, profiles of the elevations and depressions of the country on the line of the conduits, both of the interior and river route ; and an accurate exhibit of the gauges of the several streams ; also, a representation of the form of the conduits through which it is intended the waters shall pass to the city ; and of several aqueduct bridges, constructed in other parts of the world, of much greater magnitude than the one proposed to be thrown over the Harlem river. All these maps, drawings, &c. have been deposited in the office of the Street Commissioner, and await the direction of the Common Council.

All which is respectfully submitted,

STEPHEN ALLEN,
SAUL ALLEY,
WILLIAM W. FOX,
CHAS. DUSENBERRY,
BENJAMIN M. BROWN,
Commissioners.

LETTER FROM CANVASS WHITE, ESQ.

New-York, October 30th, 1833.

To the Water Commissioners
for the City of New-York.

Gentlemen,

When I received from you the appointment as one of the engineers for making the surveys and examinations for supplying the city with pure and wholesome water, I presumed that I should, in the course of the season, be able to discharge the duties assigned me; but the peculiar situation of the important public works, under my care in the state of New-Jersey, being procrastinated by the unprecedented floods, prevented my making such further examinations as was desirable. I was, however, twice on the ground, with my assistants, and made some progress in gauging the waters of the Croton river; but the storms compelled me to desist, and repair to my charge in New-Jersey; and thus the season has passed away without being able to accomplish the desirable object within the stipulated time.

I have for several years felt a deep interest in the subject of supplying the city with good water, and regret very much that my arduous duties have prevented my making such examinations this season as I had a strong desire to do, and, of course, expected of me by the Commissioners. I hope the disappointment may not be injurious to the discharge of the trust reposed in you, and that you will be able to make a satisfactory report, from personal observation and information gained from other sources.

Yours, very respectfully,

CANVASS WHITE.

ENGINEER'S REPORT.

Hon. Stephen Allen, Chairman,
Saul Alley,
Wm. W. Fox,
Benjn. M. Brown, and
Chas. Dusenberry, Esqrs.
Commissioners for making examinations relative to the supply of the City with pure and wholesome Water.

Gentlemen,

In laying before you the drafts and plans connected with the surveys and examinations, upon which I have been engaged during the season, it becomes my duty to communicate a summary report of the operations of the survey and of the results and conclusions to which they lead.

Our field operations commenced early in the month of June—having myself devoted the early part of the month to a general reconnoissance of the ground. I collected the party on the 20th at the mouth of the Croton, and began the instrumental survey. The starting point for the level was taken at the ordinary low water of the Hudson at that place, from which we ascended immediately up the side hill to the height of 170 feet, which was assumed as the average of our first trial in the valley of the Croton. The line, in the first instance, was conducted up along the south bank of the stream, harmonizing much better than I expected with the broken ground at the mouth of the Croton. At Garretson's mill, however, the slope of the bank became so difficult, by reason of the precipitous ledges of rock, that it became necessary to transfer to the opposite side, and the remainder of our line was continued on that side until it struck the bed of the river. This it did at Wood's bridge, near the confluence of Cross river, about 12 miles from the mouth of the Croton; the surface of the water, at the bridge, being 169.65 feet. From this point the line was carried, without regarding any particular average, up the north bank of the river, through Somers town and the valley of the west branch of the Croton, to a point about two miles above the county line, where a height of 230 feet was attained in the first instance, and this subse-

quently increased to 300 by the continuation of the line to the outlet of Crosby's pond, up which a trial was also made to the pond itself. From the line thus traced offsets were carried, in the progress of the survey, up the middle and east branches of the Croton and one of the tributaries of the former, rising, in each case, to about 290 feet—and a line, for connecting these surveys with those of the lower Croton, was run, by way of trial, down the left bank of the river, from Owensville to Wood's bridge. In the latter vicinity an offset line was carried up the Muscoot to Bedel's millpond, at the height of 283 feet; others, up Cross river and its tributaries, the Beaver dam and Broad brook; and another, by the valley of Muddy brook, up the Cisco; and the connection of this last down the valley of the Cisco itself, and by the left bank of the Croton to Wood's and Pine's bridges, completed the arduous but highly interesting examination of these waters; the gauging only being reserved for a drier period of the season.

It will be proper to remark in this place, that the lines just described, and all other lines instrumentally surveyed, are indicated on the map by a *red trace;* the stations being numbered, in part, so as to tally with the numbers of the field books.

The next object of our attention was, to examine the grounds south of the Croton, with a view of obtaining practical routes in the direction of the city. A very brief reconnoissance, in the first instance, was sufficient to show, that among the deeply undulating and apparently irregular hills of this region are contained the rudiments of a great ridge, dividing the waters of the Croton from those running south, and only intersected here and there by certain defiles, in which the streams of both slopes take their rise. In the first of these defiles, passing from the Hudson eastward, the stream of Sleepy Hollow running south, and a small mill stream, which empties into the Croton below Pine's bridge, running in the opposite direction, head together. In another, a branch of the Cisco and Sawmill river—in another, another branch of the Cisco and the Bronx—in another, the Cisco itself and the Wampus—and in others, farther east, the branches of the beaver dam and various waters of Long-Island Sound. It became necessary to explore all these, as well as the ground at the mouth of the Croton and along the margin of the Hudson, with reference to our object.

Without authentic information in the early stages of our work, there was a remote possibility of finding a pass among the eastern-

most of the waters mentioned, viz. the branches of the beaver dam. But in exploring these, as tributaries and feeders of the Croton, this question was soon put to rest. It became evident, that no practicable pass could be obtained in that direction.

The next line examined was that of the main Cisco and Wampus, which was levelled over from Newcastle to Wampus pond, with the following results:

Kirby's millpond on the Cisco,	344.049	feet above 0.
Dividing ridge near Wampus,	479.055	do.
Surface of water in Wampus pond,	453.469	do.
Distance from Kirby's to Wampus,	$2\frac{3}{4}$ miles.	

These heights being greatly above those to which I had generally limited my examinations on the Croton, this route was, of course, given up.

The instruments were next placed upon the line which leads to the head of the Bronx by the middle branch of the Cisco; but upon running up the latter to the height of 374 feet, and finding it still a competent mill stream at a distance from the dividing point, and with a considerable fall therefrom, this route was also abandoned.

We come next to the defile, which leads by the west branch of the Cisco into the valley of the Sawmill river, and here it was our happiness to find a very considerable amelioration in the character of the ground. The bed of the valley is remarkably uniform in shape and direction, having no immediate indication of rock near the surface, except towards the south part of the defile, and of sufficient width for any mode of construction which it might be thought proper to adopt. Its elevation, although sufficiently great in comparison with that of the Croton and its branches to present a question of some interest to the mind of the Engineer, was not considered such as to preclude the location of a practicable route, and this view being confirmed in the progress of our examination, it has been adopted, and is presented on the map as *one of the locations* for our aqueduct line. Its discussion will be resumed as soon as we shall have completed our detail of the operations of the survey.

The line from Pine's bridge, in the direction of Sleepy Hollow, was enumerated as deserving some consideration. Upon trial, however, with the instruments, it proved to be nearly twenty feet higher than the last mentioned, holding out to a more considerable distance in each direction, without any great diminution in height,

and with a regular substratum of solid rock immediately beneath the soil. It was, of course given up. In addition to the above, it was hoped in the early stages of the survey, that a line *might* be obtained among the ravines immediately back of Sing Sing, so as to cut off the broken ground near the mouth of the Croton; but, after some time and labour devoted to the examination of that vicinity, it was given up as impracticable.

The line by the mouth of the Croton and along the margin of the Hudson, was the only one remaining to be examined in connexion with the Croton waters. This was resumed near the point where our operations were first commenced, and carried downward along the face of the slope of the river, sometimes on the immediate margin of the Hudson, but often with a view of obtaining better ground, cutting into the valleys farther inland. This route nowhere presented any difficulties involving the question of practicability, as it was always *possible* to turn the flank of any obstacle on the side next the river. But in doing this it became important to guard against abrupt sinuosities, which would increase the expense of construction by the increment of length, beyond the limit of any countervailing advantage. It became necessary, therefore, in almost every step of our progress down this line, to discuss questions of detail; and the necessity of making frequent collateral trials and examinations, with reference to this object, rendered our progress comparatively slow.

The first important question of this kind, after leaving the broken ground at the mouth of the Croton and in the neighbourhood of Sing-Sing, occurred at the passage of the Mill river and Sleepy Hollow, near Tarrytown; and several days were spent in laborious examinations at this point, before a satisfactory location was obtained.

The next question of a similar kind, related to the transfer of the line from the margin of the Hudson into the valley of the Sawmill river, for which purpose several trials were made, as will be seen by the red lines on the map, between Tarrytown and Yonkers. This object being at length attained, and our line transferred to the east bank of Sawmill river, the next general object of our examination was to ascertain the continuity of the high ground, by which to sustain our level line in the direction of the city. In this respect, the ridge nearest the Hudson, below Yonkers, failed entirely, and it became necessary to penetrate into the valley of Tib-

bet's brook, and gain the ridge east of that stream. This after many trials was happily accomplished, and the survey then proceeded, without further interruption, to the crossing of Harlem river.

Before arriving at this point, however, with our Croton lines, a digression had been made from the valley of Sawmill river, near Unionville church, into that of the Bronx, and extended up the latter, so as to embrace a full survey of the Rye ponds, and a line from these to Byram river. These examinations were afterwards carried down the valley of the Bronx, and resulted in a location, commencing at Popham's Calico Factory; this being the lowest point at which it was found practicable to take the waters of this river, so as to deliver them at the requisite height in the city without the intervention of machinery.

Other routes originating at lower points on the Bronx, and which of course would require the aid of an extraneous elevating power, were not examined further than to survey with great care the *water power* of the *Harlem river*, which being found inadequate to the performance which any feasible location upon this principle would require, further examinations were deemed unnecessary. I shall return again to this subject in the following part of this report, and I trust it will be seen, that while I have given to it every consideration which its importance in the public estimation required, I have endeavoured to do so with the utmost deference to the highly respectable authorities, by which these routes have been recommended.

Our two lines from the Croton closed upon each other in the valley of the Sawmill river, near the intersection of the Tuckahoe road. That from the Bronx united with them on the heights of Fordham, and from this point a single line across Harlem river established the connexion of the three with the city. This connecting line was closed on the city plat, at the corner of 119th street and Tenth Avenue, finishing the labours of the party as such on the fourth of September; and the balance of the week devoted by myself to the gauging of the streams, and the examination of the head waters of the Croton, brought the field duties of the survey to a final close.

It will be seen from the course of the examination thus detailed, that all the routes from the Croton except *two*, were disposed of in the first trials. We now proceed to a more particular examina-

tion of *these two*, referring as occasion requires to their respective delineations on the map.

THE INLAND, OR SAWMILL RIVER ROUTE.

In the course of the examinations, with a view to determine the practicability of this route, my attention was drawn to a natural basin of solid rock, in an elevated and remarkably central position near Mechanicsville, or Wood's bridge. Its height is about 268 feet above our zero, and the view from it suggests at once the important and interesting relation in which it stands (with reference to our present object) to the waters of the Muscoot, Cross and Beaver dam, as well as to those of the main Croton. This position was accordingly chosen as the location of a reservoir, marked on the map as the confluent reservoir, calculated to receive the waters of the streams mentioned by means of iron feed pipes of the largest size. The location of these pipes is indicated on the map by purple lines, radiating in their respective directions from the confluent reservoir, and terminating with small fountain-head reservoirs in the beds of the streams to which they belong.

The Muscoot pipe, for example, radiates from the west side of the confluent reservoir, and passing up the valley of the Muscoot, terminates on the reservoir marked H, at the distance of three and one-eighth miles.

The Cross river pipe in like manner passes from the east side of the confluent reservoir, and terminates at the reservoir marked E, in the bed of Cross river, three miles distant.

The Beaver dam pipe, one and seven-eighths miles long, unites the reservoir of that stream, marked F, with the confluent reservoir, and a branch three-fourths of a mile long receives the waters of the Broad brook reservoir, marked G.

The main Croton pipe, crossing Cross river, runs up the valley of the Croton, and terminates in a reservoir on the west branch, marked C, at the distance of nine and three-quarter miles from the confluent reservoir, having a branch pipe of two miles leading up Middle brook to the reservoir D, and another of two and a half miles may be run up the east branch to the reservoir I, if it should be thought advisable to take in that branch.

These pipes, I observe again, are calculated to conduct the waters of their different fountains into the confluent reservoir; the water surface of the latter being assumed at 270 feet above tide,

and the different Fountain Reservoirs in such a relation of height as to ensure a head of from three to four feet per mile in each branch. The Confluent Reservoir not being intended for the storage of the water, as many positions better adapted to that object occur in the progress of the line, is calculated at about two and a half chains square, nearly two-thirds of an acre; but the locality admits of a construction, if such should be thought necessary, embracing an area of two acres. Other positions than that here chosen were viewed in the same vicinity, with a favourable impression of their advantages, for the purpose mentioned, and it is not improbable that in the minute survey of the ground preparatory to an actual location, some improvements may be made in the location of the pipes. The *principle*, however, will not materially vary, and the general conclusions, which are drawn from the system as described, will be equally predicable of any modification of it.

The supply of water that may be obtained at the Confluent Reservoir, by this system of feeders, deserves particular attention before we proceed to the subsequent constructions of this route. The quantities running in the different streams enumerated, at the lowest season of the present year, were ascertained by gauging with great care, on the fourth, fifth and sixth of September. There had not at that time been an entire rainy day in the vicinity since the third of July, and as a considerable rain occurred almost immediately after, it is presumed that the quantities then running were a fair minimum of the present year's supply. The results were as follows:

Muscoot,	3,628,800 galls. per diem.
Cross river,	9,142,400
Beaver dam and Broad brook,	4,963,480
Cisco,	2,073,600
West branch of Croton	5,287,680
Middle do. do.	1,252,000
East do. do.	6,155,800
Total,	32,503,760 galls. per diem.

The testimony of the inhabitants as to the state of the streams at the time of gauging, compared with that of other seasons, was, that the waters were "very low—seldom lower," and according to

the statement of some, "never." The great drought of 1816 was the only one which was generally excepted in the comparison o. seasons; and from the marks and indications shown me of the state of the waters at that time, I was led to infer that they might have been fifteen, possibly twenty per cent. lower than at the time ot my examination. It was said indeed that the Croton might have been crossed during that season without wetting the feet; but this amounts to nothing: it could be said with truth of much larger streams, and might have been done at many places on the Croton at the time I gauged it, when there were certainly not less than fifty millions of gallons daily rolling down it. The shores of the Croton and its branches have been so long cleared up and cultivated, that it is not probable the supply of water will hereafter undergo any considerable variation from further improvements; and the allowance of one-fifth, therefore, on the foregoing results, to meet an extraordinary state of the waters, such as that in 1816, must be considered as sufficiently cautious for any possible contingency.

The results reduced in this ratio will be found as follows:

Muscoot,	2,903,040 galls. per diem.
Cross river,	7,313,920
Beaver dam and Broad brook,	3,970,784
Cisco,	1,658,880
West branch of Croton,	4,230,144
Middle do. do.	1,001,600
East do. do.	4,923,640
Total,	26,002,008 galls. per diem.

Twenty-six millions of gallons, therefore, may safely be calculated upon as the daily running supply of the streams mentioned, without including the amount to be obtained by storage on the numerous lakes and spring-water ponds connected therewith. The number of these is almost incredible. I visited seventeen of them in the course of three days; of which, twelve furnish a superficial area of more than three thousand acres, and would yield, with a disposable head of only four feet, an additional supply of twenty millions of gallons daily for six months of drought; that is to say, eleven millions from the reservoirs of Cross river and the Muscoot, and

the residue from those of the upper Croton. The adequacy of the supply ceases to be a question in view of these facts.

The mill improvements, embraced within the range of the works proposed, and which might be injuriously affected thereby, are, with the exception of those on the east branch of the Croton and that at the mouth of Cross river, very inconsiderable indeed. They consist of two small mills (Bedel's) propelled from one pond on the Muscoot; four altogether on Cross river, of which Jay's gristmill and the establishment at Mechanicsville are the most valuable—a sawmill on the west branch of the Croton, and the establishments of Messrs. Owen, Finch & Brown, near Owensville on the east branch; these last being by far the most valuable of those enumerated. The views of supply would probably not comprehend all these for a long time to come, and only a partial injury would generally be sustained by those so comprehended. The amount of indemnity, therefore, cannot be very great in a country abounding with unimproved water power, as the valley of the Croton does. Further information can be furnished on this subject in a separate communication; but, in the mean time, I have included in the following estimate an item believed to be amply sufficient for this purpose, and for the purchase of such other water-rights as are contemplated in the scheme of this route.

The expense attending the construction of the different feeders enumerated is summed up as follows, viz.

Muscoot feeder ($3\frac{1}{8}$ miles long) including dam, aqueduct, &c.	268,500
Cross river feeder (3 miles long) do. do. do.	263,000
Beaver dam feeder and branches do. do. do.	229,500
	$761,000
Indemnities, water-rights, &c.	43,500
Contingencies,	50,000
Total expense of delivering the lower Croton waters into the confluent reservoir,	$854,500
Upper Croton and branches, $14\frac{1}{2}$ miles, including dams, Aqueducts, &c.	1,155,000
Indemnities, water-rights, &c.	57,000
Contingencies,	65,000
Total for the waters of the upper Croton,	$1,277,000

From the Confluent Reservoir an aqueduct is located along the slope of the Beaver dam valley into that of Muddy brook, from the head of which it passes into the valley of the Cisco, by a cut of a mile in length, averaging 18 feet deep. Thence crossing the main Cisco it follows up the west branch to its head, and by a long deep cut debouches into the valley of Sawmill river. According to the arrangement of our grade, allowing one foot fall per mile from the Confluent Reservoir, this cut takes a length of about three miles, commencing and ending at the depth of 20 feet. Its average depth, on that distance, is 38 feet, with an extreme of 55 feet at the dividing ridge.

Undoubtedly this cutting constitutes the chief difficulty of this ocation ; but, if regarded with reference to the peculiar nature of the present work, it will be found to lose much of its formidable character The mere passage of the water, without regard to the use of the channel as a navigable canal, requires only moderate dimensions of breadth and depth, no towing path, nor any great allowance of clear space, necessary in other cases, being required in this. Under such circumstances, and because most parts of the present work will require a lining of masonry at any rate, the construction of it by means of a drift way, instead of an open cutting, becomes an expedient of real economy, whenever the depth exceeds a certain limit; and we find, by the calculation of our data, that in the present case this limit does not, in fact, exceed 25 feet.

It may be observed, also, that a moderate increase of depth, not exceeding for instance 38 feet, produces no proportionate increase n the expense of tunnelling ; and the inference is, that in resorting to the construction of a regular tunnel, on all that part of our work which exceeds 25 feet, we shall practically reduce the expense and d fficulty of its construction, nearly to the standard of an open cuttmg of this depth.

The occurrence of rock, such as that generally found in the vicinity, will not materially affect the truth of this proposition. It will, undoubtedly, increase the expense of excavation ; but, on the other hand, it will supersede the necessity of arching over head, and probably of lining the channel way ; in which case, it will produce a saving rather than an enhancement of expense.

The occurrence of water will probably be an evil according to any mode of construction, and must be provided for in the preparatory arrangements. In the construction of a tunnel, however, it

will be practicable to establish a simple drainage at an early stage of the work, through the whole line of the drift, by running a small headway from the flanks, towards the centre, in connection with the shafts.

The time necessary for executing this work under less favourable circumstances, would be tedious ; but with a surface so slightly elevated above the grade, and in other respects favourable, it may be carried on, by the multiplication of shafts, almost with the celerity of an open cutting. The plan of construction recommended for the generality of the line between the confluent reservoir and the tunnel, is a plain channel-way of masonry, either dry or in mortar, represented in form, though not exactly in size or construction, by draught No. 1. For the locality referred to, it should be about 6 feet wide at bottom and 8 feet at top, by 5 or 6 feet deep ; and to protect the bottom against the abrasion of the current, it should be covered with a heavy layer of the masonry composition called bêton—or better, by a reversed arch of hard brick, laid with cement in a prepared mould of the bêton ; finally, the whole to be covered over with a shingled or boarded roof. With the foregoing dimensions, and the declivity of one foot per mile, the quantities of water discharged would be as follows, viz.

When running with the depth of 2 feet=9,837,000 galls. per diem.
do. do. 3 do.=17,903,600 do. do.
do. do. 4 do.=29,948,800 do. do.
taking the nearest hundred in each case.

The expense of constructing a channel-way of the kind here described, and in the best manner, is estimated at about 48,000 dollars per mile, including the roof; but in cases where the nature of the soil or the regimen of the current permits us to substitute bêton for the reversed arch, the expense will be reduced to 43,500 dollars, exclusive of excavations. When the cuttings become somewhat deep, as they do on about 3¼ miles of the first twelve, it will be expedient to adopt the form and proportions of the drawing No. 2, filling in with earth over the arch ; and the same profile may be used also in the tunnel, wherever the roof of the excavation consists of earth. This will make the expense of the construction about 58,000 dollars per mile. In rock excavation, however, the expense of the masonry construction will be diminished

at least 15,000 dollars per mile, and in some instances more ; and in the tunnel, wherever the vaulting can be dispensed with, the preparation of the channel-way will probably not exceed 15,000 dollars per mile altogether.

From these data we may now estimate the expense of the first twelve miles, as follows :

Cutting and filling on $9\frac{1}{2}$ miles of open cutting, (including culverts)	61,420
Excavation on $2\frac{1}{2}$ miles tunnel, including shafts, &c. one-fourth rock,	114,000
Construction of channel-way, including the Confluent Reservoir,	558,000
Total,	$733,420

The bed of Muddy brook north of the dividing ridge, as well as that of Sawmill river at the debouch of the tunnel, furnish favourable positions for storing reservoirs, one of which, at the last mentioned place, is represented on the map at the distance of $12\frac{1}{8}$ miles from the Confluent Reservoir, and which may be constructed, if adopted, without any enhancement of the foregoing estimate. The draft of water taken from it is supposed to be 247 feet above tide, the surface of the reservoir itself being 258 feet, and the declivity of the location down the residue of the Sawmill valley is assumed at 6 feet per mile. The local circumstances of this part of the line are singularly favourable—the lateral slope of the ground generally gentle, presenting an easy choice of levels, with very few positions requiring cutting or filling to any extent, or much extra work of any kind whatever. A general profile for the construction of the channel-way, under these circumstances, is exhibited in the annexed drawing, No. 3. Its dimensions are adapted to the proposed declivity, so as to give nearly the same discharges at the different depths that are given on a less declivity by the larger profile above specified, and the expense of its construction, in the best manner, is estimated at 35,500 dollars per mile.

The drawing, No. 4, is given to meet cases of deep cutting ; but its application, on this portion of our route, will be very limited indeed.

The entrance to Tibbet's brook valley is effected by a cut 12 chains long, 28 feet deep at the highest point, and about 22 feet at an average, chiefly in rock. It is located on the map as a deep cut following the curve line of the gap ; but if a tunnel should be substituted, it would, of course, take the chord of the curve, and shorten the distance about one chain. This mode of construction is also advisable, in reference to the highway, which, at present, occupies the gap, and for the accommodation of which it would be necessary to close the entire thorough cut, *if constructed*, with a strong archway of masonry. The tunnel will require no archway, and will undoubtedly be the preferable construction in point of economy. The valley of Tibbet's brook furnishes another favourable location for a *storing reservoir*, the construction of which would merely require a *dam*, instead of an aqueduct, for the passage of the brook.

The area which may be included, is about 40 acres in extent, and is surrounded on all sides, except where the dam would be, by high steep hills ; the whole having an air of seclusion and cleanliness well adapted to the end in view. The surface of this pond would be graduated by its distance from that at the head of the Sawmill valley, allowing the proposed rate of descent equal 6 feet per mile, which would make it $147\frac{1}{2}$ feet above tide. The draft from it may be taken at 140 feet, and the aqueduct on the remaining distance to the city is proposed to be graded at a fall of 2 feet per mile, using, of course, an increased channel-way. This arrangement of grades, from the head of the Sawmill to the city, is found to meet the conditions of the ground between Tibbet's brook and Harlem river more advantageously than a grade of uniform fall; otherwise the latter would have been preferred for its simplicity.

The crossing at Harlem river is proposed to be effected by means of an Aqueduct bridge, 18 chains, or 1188 feet long, from abutment to abutment, and consisting of nine plain semicircular arches. The position in which it is located on the map is the narrowest at the height of the grade line, which the ground admits of, and is furnished with natural abutments of solid rock on both sides of the river. The river itself, including a small margin of low ground, is about 600 feet wide, and on this distance (comprising five or six of the piers) the height of the structure from water line to water line would be 126 feet, exclusive of hydraulic foundations,

which would be from 10 to 25 feet more. Our structure adapted to these dimensions would of course be a work of considerable labour and expense, but by no means of paramount difficulty in either of these respects. Many bridges of much greater magnitude, both in length and height, have been erected in other countries for the same object, from which we are enabled to derive certain data for all our calculations. The aqueduct bridge of Lisbon, for example, of which a fragment is exhibited in the annexed drawing No. 5, consists of 35 arches, some of them more than 100 feet span and 230 feet high. The modern aqueduct bridge of Caserta, near Naples, (see Fragment No. 6,) is upwards of 1600 feet long by 178 feet high, and consists of about 90 arches in three tiers. The aqueduct of Spoletto (No. 7,) consists of ten arches, somewhat narrower than ours, but in height upwards of 300 feet; and the iron canal aqueduct of Pontcycylte, in Wales, (No. 8,) is 960 feet long and rests upon 18 piers of brick, some of which are 120 feet in height. Numerous other examples of a like kind might be quoted, but it may suffice for the present to name two only in addition to those already mentioned, viz. the great aqueduct of Maintenon, in France, of 666 arches, projected by Vauban and partly built, being three and a quarter miles in length, and of various heights from 50 to 220 feet. And lastly, the recently constructed aqueduct of Lucca, of 1000 arches.

With such examples of enterprise and skill before us, many of them undertaken for objects far less important than that of supplying the city of New-York with water, we may certainly look upon the design of the Harlem aqueduct without fear.

From the aqueduct, passing south, the line for about half a mile encounters a precipice of rocks; it then attains the surface of the ground, and soon afterwards falls into the line of the tenth city avenue. At this stage of the location, a question of some importance presents itself, as to the most favourable locality for the Receiving Reservoir. A position admirably adapted to this purpose, being bounded on two sides by ledges of rock, presents itself between the Ninth and Tenth Avenues, on the north side of the Manhattanville valley, from which mains could be taken for the supply of the Distributing Reservoirs, without any extraordinary expense in crossing that valley. On the other hand a more active and efficient head would be obtained, by extending the structure of a regular aqueduct across the valley, and so continuing it to some po-

sition for the Receiving Reservoir further south ; or we might cross the valley by an inverted syphon of sufficient capacity, and renewing our head by means of a reservoir on the south side, continue the structure of the aqueduct therefrom, say to 104th street, in the vicinity of the Ninth Avenue, or possibly as far south as 85th street, in which vicinity, I understand, there are lands belonging to the Corporation, some of which might be adapted to the location of this reservoir.

Our surveys contemplated the ground with reference to all these methods, but our location is delineated according to that first mentioned; in doing which, however, it is by no means intended to prejudge the question; indeed it is more than probable that the plan *last* mentioned, upon further examination, will be found to possess superior advantages in point of efficiency, without much if any enhancement of expense.

The system and construction of the Reservoirs for receiving and distributidg the water, would be nearly the same for either mode of arranging the line of conduit; that is to say—

First, the Receiving Reservoir, which we may suppose to be in the position named, viz. between Ninth and Tenth Avenues, and between 133d and 137th streets. This, if made to occupy the entire space here indicated, would afford two apartments of eight acres each, enclosed with a rampart of earth and masonry, sufficiently broad for a border of clean shrubbery and trees. The average height of its water surface would be about 123 feet.

Secondly, two Equalizing Reservoirs; one on 105th street, between the Eighth and Ninth Avenues, and the other on 69th street, east of the Eighth Avenue. These may be of any dimensions, from one to eight acres. The *first* receiving its water along the line of the Ninth Avenue, and the *second* by a main from the first, along the Eighth Avenue. Of course the first would be dispensed with as an Equalizing Reservoir, in case its position, or any more southerly position, should be occupied as the locality of the Receiving Reservoir.

Thirdly, the principal Distributing Reservoir, for which the most favourable position appears to be near the intersection of 38th street and Fifth Avenue, three miles from the City-hall; this being the most southerly point, at which an elevation nearly great enough can be obtained, and where the area is sufficient to afford the desired capacity. It is proposed to occupy at least two entire blocks

with this reservoir, which, after giving a strong profile to the enclosing rampart, will afford a clear area of eight acres, and contain more than fifty-two milions of gallons in volums, to a depth of twenty feet. Its water will be conveyed from the second equalizing reservoir, by a line of conduit laid down along the Eighth Avenue to the corner of 38th street, and thence by the latter to the Distributing Reservoir.

The effect of the whole arrangement will be generally to maintain an equable head at the highest possible elevation in the Distributing Reservoir, and to furnish a prompt supply on occasions of extraordinary draft. If, for example, the surface of the Distributing Reservoir should be drawn down much below its ordinary lével, the increased difference of head would tend immediately to restore the deficiency, by an accelerated passage of water from the nearest Equalizing Reservoir; and this in turn would be supplied by a similar action from the next in order, and so on till the equilibrium of the system was entirely restored. This tendency, therefore, operating by night as well as by day, would secure the Distributing Reservoir against any considerable variations of level, and supposing the supplying mains properly constructed and arranged, it is presumed that the average height of its water line would not stand many feet below that of the Receiving Reservoir, probably five or six, which would still afford a head of 117 feet above tide for the distribution of the water. This is about fifteen feet greater than the height of the Fairmount reservoir at Philadelphia, and abundantly sufficient for all practical purposes in the city of New-York.

The length of the line thus described, from the Confluent Reservoir near Wood's bridge, to the Receiving Reservoir at Manhattanville, is 37 miles and 52 chains; and from the latter to the Distributing Reservoir on 38th street, five and a half miles; making a total of the route as located of 43 miles and 12 chains, without including the pipes for collecting the water at the Confluent Reservoir.

The expense of the first twelve miles, including the Reservoir at the head of Sawmill river, has already been given, and it only remains now, in completing our views of this route, to give the *estimate* for the remainder, as follows: viz.

Cutting and filling from the Sawmill Reservoir to the Receiver,	$191,250
Harlem Aqueduct, two small Aqueducts, Tibbet's Dam and several small culverts,	576,000
Channel-way complete,	1,020,000
Receiving, Distributing and Equalizing Reservoirs on the island,	200,000
Five and a half miles of supplying main, at $100,000 per mile,	550,000
	$2,537,250
Add estimate of first twelve miles,	733,420
Total nett cost from Confluent Reservoir,	$3,270,670
Contingencies,	325,067
Land and water rights, damages, &c. &c.	100,900
	$3,695,737
To which if we add the expense of the lower Croton Feeders,	854,500
We get an aggregate of	$4,550,237

This is the estimated expense of delivering the water of these feeders into the distributing reservoir in the city; that is to say, at the *minimum*, 15,846,624 gallons per diem of *running water*, and 11,000,000 obtainable from a surface of 1600 acres of reservoir. The upper branches of the Croton, whenever it shall become necessary to resort to them, will furnish an additional supply of 10,155,384 gallons per diem of running water, and 9,000,000 more from spacious natural reservoirs, and the additional expense, as heretofore estimated, will be $1,277,000; making a total for the entire system, $5,827,237.

HUDSON RIVER ROUTE.

This line takes its origin from a reservoir at the foot of Muscoot hill, marked A, where a dam of thirteen feet will back up the water to a considerable distance above Wood's bridge, and spread it over a portion of the flats at the confluence of the Muscoot. The reservoir thus formed would have a surface of about eighty acres,

from which it is proposed to clear off the loose soil, trees, and growth of every kind. The height of the fountain-head thus formed will be 175 feet above tide. Another plan of deriving the water, so as to avail of a height somewhat greater, was discussed in the progress of the survey, and is as follows, viz. to intercept the Croton a little below Golding's Bridge by a dam of about nine feet in height, which would give an elevation of 191 feet above tide at the fountain reservoir in this position. Thence leading the water by a short cut down the east side of the river into the Factory dam at Mechanicsville, raising the latter about three feet for the purpose, and finally retaking it from the south end of the dam, and conducting it along the face of the slope down the Croton. By crossing the Croton at Muscoot hill, we should be enabled at a future time to bring in the water of Muscoot river by a short feeder, originating in the reservoir marked R, so that the entire Croton would become available by this arrangement, the same as in taking the water from the reservoir A. The height gained at the foot of Muscoot hill by adopting this plan, would be about ten feet, an important consideration in locating the residue of the line down the Croton; but whether sufficient to compensate for the additional constructions, must remain for the present undecided.

The location to be explained and estimated is considered as originating at the reservoir A ; the water being taken at the full height of the surface, with only a fall in the first instance necessary for imparting the initial velocity. As to the adequacy of the supply, a very brief statement will suffice. It was on the fifth of September that I gauged the Croton at Wood's bridge, and it was then discharging at the rate of 51,522,480 gallons per diem ; to which if we add the 3,628,800 discharging from the Muscoot, and reduce the aggregate in the ratio of one-fifth, to meet extremes of drought like that of 1816, we have still remaining a regular running supply of 44,120,924 gallons per diem, without resorting to the 20,000,000 daily, obtainable from reservoirs.

The general rate of declivity for the line under consideration, is assumed at one and a quarter feet per mile, which is maintained regularly from the fountain head to the city. The channel-way adapted to this declivity is that represented in the drawing No. 1, already referred to, being four feet wide at bottom and six at top, and six feet deep, including the reversed arch of one foot; with

which dimensions it will deliver the following quantities of water according to the different depths at which it runs, viz.

At 3 ft. measured in the mid-channel,	11,500,000 galls. per diem.
4 ft.	17,905,215
5 ft.	25,985,235
6 ft.	33,516,000

The vaulted profile, No. 2, is adapted to deep cuttings, and to the passage of roads and villages on this route, having the same capacity as the preceding for the delivery of water. The expense of these different constructions, will vary as was mentioned in the inland route, according to the nature of the strata in which they are severally executed, being always most expensive in soil and least so in rock, regarding the masonry apart from the excavation; and in a majority of cases the same relation also obtains in the aggregate. It will be seen of course, that this arises from the increased quantity both of excavation and masonry, necessary in the case of soil. With regard to the *masonry* alone, if done with mortar in a durable and substantial manner, with reversed arch, the cost will be as follows: For the profile No. 1, in soil, roof included, $48,688 per mile; and in rock, $34,848; and for profile No. 2, an addition of 10,500 dollars in eacn case.

It is rather fortunate than otherwise then, that rock does occur on a considerable proportion of this route; it is only when it presents itself in the form of steep precipices and sharp points, or in great heaps of loose rock, that it becomes more expensive.

With regard to the cuttings and fillings on this route, I presume it will not be necessary for me to describe them in detail; they are fully exhibited in the accompanying profiles, and the single remark, that the location, until it penetrates the Sawmill valley, is wholly traced along the undulating hill-side of the Croton and Hudson vallies, will explain why the excavations and embankments are so much more numerous and bold than those of the *inland route*, excepting only the deep cutting on that route. The following remarks are added, relative to a few prominent points of difficulty, where principles of construction or location are involved. The first case of this kind occurs at the point of crossing the Croton at Garretson's mill, where an aqueduct of one arch 85 feet span will be required, and a land arch of 16 feet for the passage of the road. The *shoring* is favourable, particularly on the south side, which is a steep precipice of rock; height of the grade line 40 feet. Some

heavy culverts occur on the following parts of the line, but the next work of much magnitude is a short deep cut of 35 feet extreme depth near the mouth of the Croton. This is made in passing an isthmus back of the hilly grounds of that vicinity, and cannot be avoided without encountering other impediments of much greater account. It is estimated as a deep cutting, but probably would be lessened in expense by admitting a short tunnel in place of an open cut. Another of the same depth, but shorter, occurs nearer Sing-Sing, through which there can be no doubt of the expediency of a tunnel.

The chasm of Sing-Sing hill next occurs, and will require a bold culvert of 60 feet span; after which about a mile of the line passing through Sing-Sing will require vaulting.

The next structure worthy of particular notice, is the aqueduct at the crossing of Sleepy-Hollow; this will require five arches of 70 feet span, and including wings, will be nearly 500 feet in length. The height of its water line above Mill river is 60 feet, but the banks rise rapidly, particularly that on the west side.

Passing Tarrytown, a cutting of 26 feet extreme depth occurs near Mr. Irvings, and several heavy culverts in the vicinity of Greensburg landing, one of which will require a span of 20 feet. The deep cutting by which the line penetrates the valley of the Sawmill river below Mr. Constant's, will be noticed as a prominent feature in the general profile; it is 45 chains long, beginning and ending with the depth of 25 feet, and averaging 37 feet deep on that length, chiefly rock. From the observations made relative to the tunnel on the *inland route*, the suitable and most economical construction for this locality will be readily inferred, and it results from a comparison of estimates, that to pass this dividing ridge with the minimum of expense requires a tunnel of at least half a mile.

The next work of consequence is the aqueduct across Sawmill river; this should consist of three arches of 60 feet span, making a total length, inclusive of wings, of 250 feet; its height above the surface of Sawmill river being 36 feet.

The Hudson route here falls upon nearly the same ground with that of the interior, but differs from it in the magnitude of some of its works, in consequence of the difference of grade, the river line being the lowest. In consequence of this difference, the tunnel at the entrance of Tibbet's brook will be about fourteen feet deeper

and one or two chains longer than that specified for the interior route ; which of course would decide the preference for this mode of construction, if there were any doubt in the *former* case. The depression of the river line after passing this ridge becomes an advantage for crossing the following *ravines*, and the valley of Tibbit's brook. On the east side of the latter the two lines converge more nearly to the same grade, and the subsequent ccnstructions, including the system of reservoirs and supplying mains in the city, are very nearly the same for both. They have already been sufficiently explained in connexion with the inland route. The distance by the line thus described, from the Muscoot dam to the receiving reservoir, is 41 miles and 36 chains, which, together with the five and a half miles from the receiving to the distributing reservoir, makes a total of 46 miles and 76 chains, nearly 47 miles.

The expense of constructing this line is summarily estimated as follows :

Cutting and filling, including the dam and small culverts on the whole line,	$674,652
Eight aqueducts, of which those of the Harlem, Saw-mill river and Sleepy-Hollow, are the most considerable,	812,000
Channel way, 35½ miles in soil, residue in rock,	1,985,800
Reservoirs and mains in the city as before estimated,	750,000
	$4,222,453
Contingencies,	422,245
	$4,644,697
Land and water rights, damages, &c. &c.	73,500
Total for the river route,	$4,718,197

In drawing out this estimate, as well as those given in the preceding part of this report, it may be useful to remark that every calculation has been made on the side of stability and permanency. The works are all supposed to be constructed of the best and most imperishable materials, put together in the strongest manner ; the head reservoirs to be cleared of all their soil, trees, and vegetables, and surrounded by a regular bank ; the *dams* and *weirs* to be built

of massive stone masonry; the *water-way* of masonry, as already described, closed either with a roof, or with an arch; the earth thrown back upon it, and furnished with ventilators at suitable intervals; small *culverts* to be constructed by iron pipes set in the foundations, or in the upper part of the walls of the channel-way, as occasion may require; larger culverts and aqueducts to be built of the best stone work, in a plain substantial manner; embankments generally to be formed of stone. According to these various suppositions every piece of work, of whatever kind, has been calculated separately on the respective routes, and the results, collected and classified, furnished the different items of the foregoing estimates.

The structure of masonry has been adopted for the line of aqueduct instead of iron pipes, on the ground of its *superiority*, in point of *cheapness*, *durability*, and *efficiency*. As a difference of opinion however exists on this subject, I beg leave to present it a little in detail.

1st. In point of cheapness. The structure of masonry for the Hudson River Route is estimated in ordinary cutting, at a fraction less than 49,000 dollars per mile. When vaulted through deep cutting, it will cost more, but in rock *less;* say 49,000 at an average. The excavations and culverts average on the same line, about 16,500 dollars per mile, making in all 65,500 dollars per mile. To this I add five per cent. as the ratio in which the line may *possibly* be increased *in length* and cutting by the adoption of this system, and the entire amount, to be used as a term of comparison, will be 68,775 dollars per mile, which is about six thousand dollars *less* than the estimated expense of laying down a single iron main 30 inches in diameter. The structure recommended for the Sawmill route, being much smaller in all its dimensions, comes into the comparison with an advantage of from 25 to 30,000 dollars per mile *less* than an iron pipe.

2ndly. In point of *durability.* We have no sufficient experience of the durability of *iron pipes,* to be able to bring them in a direct comparison with the *aqueduct* in this respect; we only know that the *principle* of this construction was applied *in lead,* and in a very perfect manner, in many of the Roman works, all of which have long since gone to decay, while a good number of their aqueducts are still in full operation.

We may, however, form some opinion of the relative durability

of the two modes, by a comparison of the wear and tear to which they are exposed. On an aqueduct the water flows with an easy natural motion, acting upon its channel with nothing more than its own proper weight, and a friction, scarcely appreciably; and if by an accident its motion should be obstructed, the water having room to expand, would back up and check the velocity of the approaching current without any sensible revulsion upon the sides of the aqueduct: but in a close pipe, having such a depression as would be necessary in the present instance, say 130 feet below the head, the action upon the sides of the pipe would be about 60lbs. to the inch. The water being also confined latterly, any impediment would necessarily react in some degree upon its *whole* volume, as far back as the nearest vent, and it should be observed that a mile of pipe contains more than 700 tons of water. It is true that the probability of any serious impediment is very remote, but even the friction upon so inelastic a substance as water, and under this high pressure and impetus, is a force which at no distant period must impair the stability of the work.

3dly. In point of *efficiency*. The profiles recommended for the respective routes are adapted to the delivery of any quantity up to 30 millions of gallons daily. The present demand is probably not more than six millions; but at the rate of increase by which the city is advancing, and which it would seem is *itself* increasing, at least 10 millions will be required within a few years after these works can be completed. It would be absurd therefore to adopt in the calculations of the present question a scale of supply lower than 10 millions, even for present purposes.

At the declivity adopted for the Hudson River Route, a single 30-inch pipe would deliver three millions of gallons daily; fewer than four such pipes therefore would not deliver the quantity required; and if we should attempt to reduce the number to *two* by increasing the rate of declivity to 4 feet per mile, this fall from the Muscoot Dam to the Distributing Reservoir, would carry us 17 feet below the surface of the Hudson!

The Sawmill Route after passing the dividing ridge, has a much greater declivity, but even there, fewer than *two* pipes would not suffice to deliver the quantity required. These calculations, it will be observed, are limited to the wants of the moment. As the demand increases, additional pipes would have to be laid down from time to time, at a great labor and expense. On the Hudson River

route indeed the intervals would be so short, that a corps of mechanics would scarcely be dismissed from one job, before it would be necessary to prepare for another.

These considerations, I presume, will fully justify the adoption of the aqueduct instead of the close pipe, in all cases which admit of its use.*

The idea has been suggested that the crossing of the Harlem River could be economized by the use of close pipes in the form of an inverted syphon,—somewhat in the manner of the old Roman work at Lyons. It would be easy to show by a comparison of estimates, that there would really be nothing gained in the respect contemplated by making this substitution, and in all *other* respects it would be decidedly objectionable. These details however, do not involve the *practicability* of the works, and really belong to a more advanced state of the examinations.

In the views presented by the *two routes*, no attempt has been made to institute a comparison between them. It will be seen, I trust, from the facts communicated, that the water of the Croton may be delivered in the city without any insuperable difficulty, by either of them; and this problem being solved, we may leave the question of preference to be decided by future examinations directed to that particular object.

The quality of the Croton water and its fitness as a source of supply for the city, demands a momentary notice among the subjects of this report. To the Commissioners indeed, who have informed themselves on this point by personal examinations, no such notice would of course be necessary, but to those who have not enjoyed this opportunity, a summary of the facts may not be uninteresting. The supplies of the Croton are derived almost

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* The exposure to frost which has sometimes been urged as an objection to an open canal, will be no just ground of apprehension in the aqueduct, as here proposed. The depth at which it will generally be placed in the ground—its entire enclosure overhead, and the *manner* of that enclosure by an arch-way in part, will protect it against any extreme of cold that would be likely to act upon a surface, moving at the rate of 125 feet per minute. And even if a moderate cake of ice should be formed—on a surface so small, compared with the depth and volume of water rolling beneath it—no serious evil could possibly ensue. It would rise with any *increase* of volume as the ice upon a Tide-water rises, and being protected from the wind and from all the inequalities of an ordinary stream, would rest quietly upon the surface until redissolved.

exclusively from the elevated regions of the "Highlands" in Westchester and Putman counties, being furnished by the pure springs, which so remarkably characterize the granitic formation of that region. The ponds and lakes delineated on the map, and spoken of in a former part of this report, are among the number of these springs; many of them 3 or 400 acres in extent, and *one* as large as a thousand acres. All these ponds are surrounded by clear upland shores, without any intermixture of marsh; and the surrounding country, cultivated, as it is generally, in grazing farms, presents an aspect of more than ordinary *cleanness*. The water, as might be expected under such circumstances, is perfectly soft and clear, much superior in the former respect to the waters of our western lakes, and fully equal in the latter.

The Croton fed by such springs could scarcely be otherwise than pure, and the fact of its purity was strongly verified by the experience of the party in every stage of the water during the season. Specimens were taken up both in the high and low state of the river, and have been analyzed by Mr. Chilton, and the results obtained fully corroborate these statements. It appears from his report annexed, that the quantity of saline matter, probably the salts of lime and magnesia, does not exceed $2\frac{3}{10}$ grains in the gallon, "a quantity," he observes, "so small, that a considerable quantity of the water would be necessary to determine the proportions." About two grains of vegetable matter was also suspended in the water, in consequence of the rapid current in which it was taken up, and which would of course subside in the Receiving Reservoir.

It remains yet to notice the results of our examinations on the Bronx.

The use of these waters was understood to depend essentially upon the adequacy of the supply, and the investigation of this question, therefore, would naturally have engaged our *first* attention, if it had not been necessary from other circumstances to defer it till after the examination of the routes.

In the location of these routes, generally heretofore, it seems to have been an object, and certainly is a one of no little importance, to avoid, as far as practicable, interfering with the numerous mills and factories on the stream, by taking the water from the River, at the lowest point possible, and depending upon the Tide Power of Harlem River to elevate it afterwards to the height necessary for distribution and use in the city.

A line of this kind for example, supposing it in other respects practicable, might be taken from a point near the mouth of the Sprain, so as to leave Underhill's Mill and the valuable Cotton Factory at Tuckahoe, untouched, and conducted to the bank of Harlem River, at the height of 50 feet above tide. The power of the Harlem would then be required to elevate it to the height of the Receiving Reservoir, which, being assumed as with reference to the Croton waters, makes the *additional* elevation 73 feet. Upon calculating the power of the river, however, from a careful survey of the present pond, it was found incapable of raising to that height more than 4,939,000 gallons per day; and as this would leave a deficit of two or three million gallons per day—even for present purposes, *at the time of completing the works*—it was thought unnecessary to pursue the examination of these routes any further.

The line provisionally located,—and which has already been adverted to in a former part of this Report,—commences at Popham's Calico Factory, the Dam of which will require rebuilding and raising, so as to give a head of 142 feet above tide. The locality is favourable for the construction of the Dam; but the surface of the pond, being bounded by high ground on either hand, is limited to a few acres in extent. The water would be drawn from the Dam on the west side of the river, and the location continues wholly on that side to the city, taking the same ground from the vicinity of Fordham church that is occupied by the routes from the Croton. The generality of this line is, by no means, unfavourable;—the only item of considerable expense, before intersecting the Croton routes, being an aqueduct of 740 feet, with an extreme elevation of 57 feet, at the crossing of the Sprain;—length of the line from Popham's Dam to the Receiving Reservoir $15\frac{1}{2}$ miles, and to the Distributing Reservoir 21 miles.

This line was surveyed and located with great care; but after gauging the streams, it was not thought necessary to profile or estimate it, and I presume a more particular description will not be required, after the results of that part of the examination shall be stated.

On the 15th of August I gauged the outlet of the Rye ponds, and found it discharging 950,400 gallons per day. On the 20th, and again on the 5th September, it was discharging very nearly the same quantity; but between the last two dates, a period of 15 days, it had fallen, having been drawn down by the proprietor $2\frac{6}{10}$ inches.

This draught, calculated upon the surface of the pond, = 205 acres, gives a daily decrease of 957,500 gallons in the volume of the pond ; showing that, during the time observed, the supplies of the pond, from whatever quarter they come, were in quantity about 7000 gallons per day *less* than the evaporation.

By damming the valley, about three-fourths of a mile below the small pond, so as to back up the water to three feet above the ordinary level of the *upper pond*, a reservoir of 360 acres will be formed; and by deepening the outlet of the upper pond, so as to command a draught of five feet in all, we shall obtain a volume of 705,672,000 gallons, or 3,920,400 gallons daily, for 180 days of drought. Deducting from this the daily loss by evaporation = 1,633,500 gallons, which is the lowest admissible calculation for the six warm months, we obtain a disposable surplus of 2,286,900 gallons per day. This is believed to be the maximum which should be calculated upon from the *storage* of the Rye ponds ; and the writer is not aware of any source from which it might be *advisedly* augmented. A small additional supply is doubtless obtainable from Byram river, if it were not necessary, in availing of it, to resort to the territory as well as the waters of another state.

The *running* supply of the Bronx was ascertained on the 4th and 5th of September. It was necessary to repeat the gauging several times in order to separate the accidental flow of the mills from the regular discharge of the river. The latter, however, was at length satisfactorily ascertained, viz. 4,331,880 gallons ; and reducing this in the ratio of one-fifth, for the reason heretofore mentioned, we get 3,465,504 gallons as the daily summer flow in seasons of extreme drought. Add to this, the quantity above estimated from the Rye pond reservoir, = 2,286,900 gallons, and we have the aggregate of 5,752,404 as the amount of all that can *safely* be depended upon from this quarter.

In drawing up the foregoing statements, it will be seen that I have restricted myself to a *general outline* of the facts and principles concerned—avoiding, as far as possible, all details not strictly necessary for the elucidation of the main question. It would have swelled this Report to an unreasonable length had I embraced even a small portion of the *particulars* contained in the Books and Drafts of the survey, or of the researches and calculations upon which many of the statements are founded. These, however, are retained

on file, and will be cheerfully communicated whenever their application can be of use in the further prosecution of the work.

In conclusion, I beg leave to express my strong sense of the zeal and faithfulness of the gentlemen who composed my party. Some idea of their claims, in this respect, will be inferred from the fact, that, in about ten weeks, we levelled upwards of 200 miles, and traversed more than 3400 courses, a large proportion of which was in woods or upon ground otherwise difficult and rough.

The roll of the party, at the commencement, was as follows—viz.

George W. Cartwright, Traverser.
Edward Ogden, Leveller.
W. B. Burnett, U. S. A., Wm. R. Casey, James H. Bell, } Rodmen and Assistant to Leveller.
H. T. Anthony, P. S. Noxon, } Assistants to Traverser.
R. F. Livingston, George C. Shæffer, } Volunteers.
Robert Gurling, Laborer.

Messrs. Livingston and Shæffer were associated, in the first instance, as volunteers, but were taken to supply vacancies soon after the organization of the party, and acted as Assistants to the Leveller and Traverser during the residue of the survey.

Mr. D. H. Burr, of the city, has also rendered valuable assistance as Draughtsman.

All which is respectfully submitted,

D. B. DOUGLASS,
Civil Engineer.

New-York, 1st *Nov.* 1833.

MR. CHILTON'S REPORT.

EXAMINATION OF THE CROTON RIVER WATER.

1. The application of re-agents to the water showed the absence of sulphuric acid and sulphates; and the presence of lime, magnesia, carbonic acid, muriatic acid, and vegetable matter.

2. By evaporation to dryness, resolution of soluble matter, and filtering, a residuum was obtained, which dissolved in dilute muriatic acid with effervescence, except a portion of vegetable matter.

3. The watery solution of soluble matter (in No. 2) contained muriate of magnesia and vegetable extract, without lime.

4. The muriatic solution (of No. 2), which in its formation was attended with effervescence, contained both lime and magnesia; the matter dissolved therefrom must have been the carbonates of these earths.

From these results we are authorized to consider muriate of magnesia, carbonate of lime, carbonate of magnesia, and vegetable matter, as the only ingredients of the water.

5. A half-gallon, principally from the bottle marked ⊕,* yielded, by evaporation, 2.333 grains residuum moderately dried, consisting of

Vegetable matter,	.133
Carbonates of lime and magnesia,	1.200
Muriate of magnesia,	1.000
	2.333 grains.

* Taken from the Croton, at Wood's bridge, at low water.

6. No. 1 and No. 2, a quart of each, yielded 1.3 grains, which is †2.6 grains of dry residuum for the half-gallon, consisting of

Vegetable matter,	0.125
Carbonates of lime and magnesia,	1.375
Muriate of magnesia,	1.000
	2.500 grains.

7. ‡Six pints, from two bottles, yielded only 2.1 grains of dry matter, the vegetable matter reduced to charcoal and burnt off. This gives for the half gallon 1.4 grains.

The average of these three separate results is, for the half-gallon 2.08 grains, or for the gallon, 4.16 grains.

The quantity of vegetable matter being not only different in the different samples, but dried at different temperatures, may have occasioned, in good part, the difference apparent in the above results. From experiment (7) it seems to follow, that the quantity of saline matter cannot exceed 2.8 grains in the gallon, a quantity so small that a considerable quantity of the water would be necessary t determine very minutely the proportional quantity of each of its ingredients.

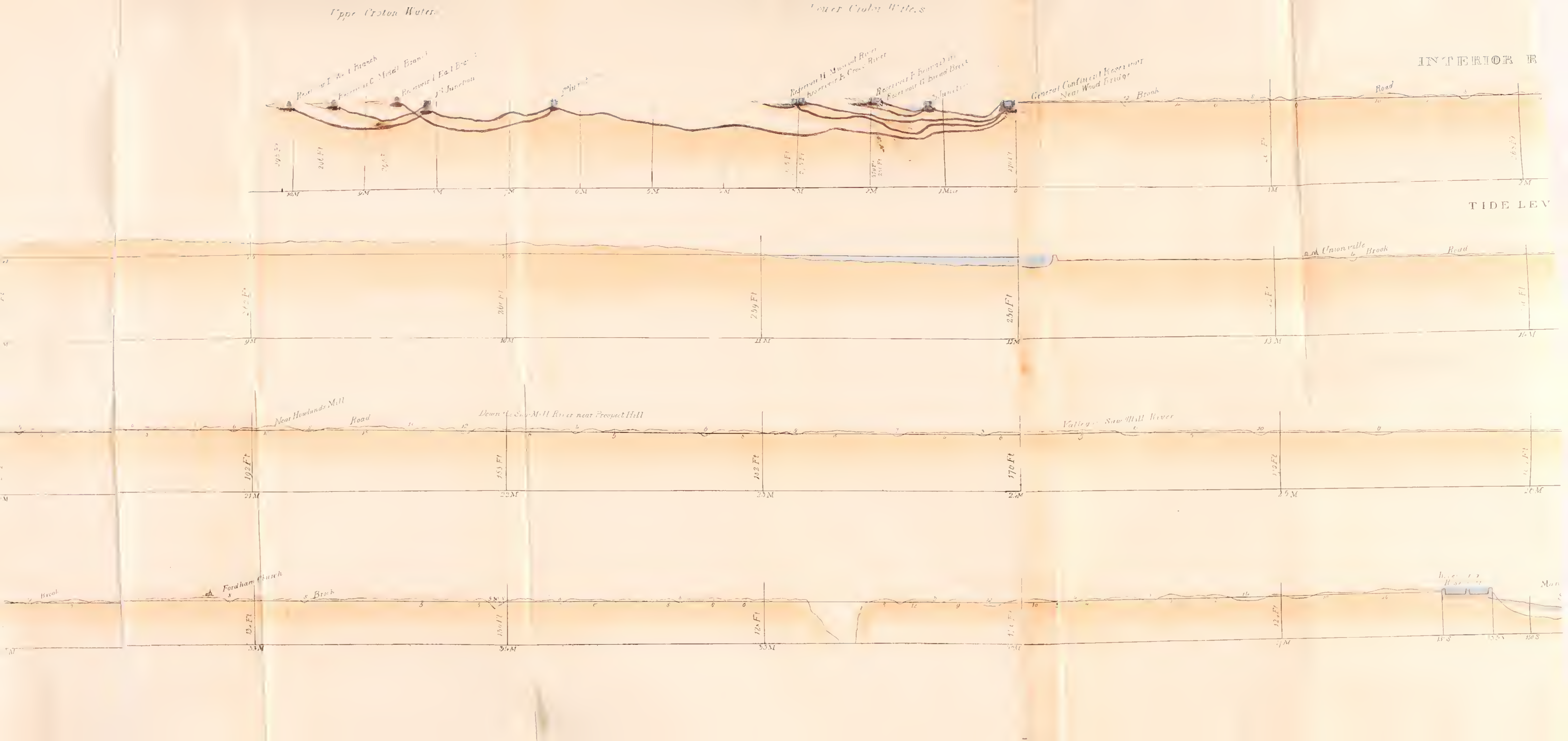
(Signed)

GEORGE CHILTON.

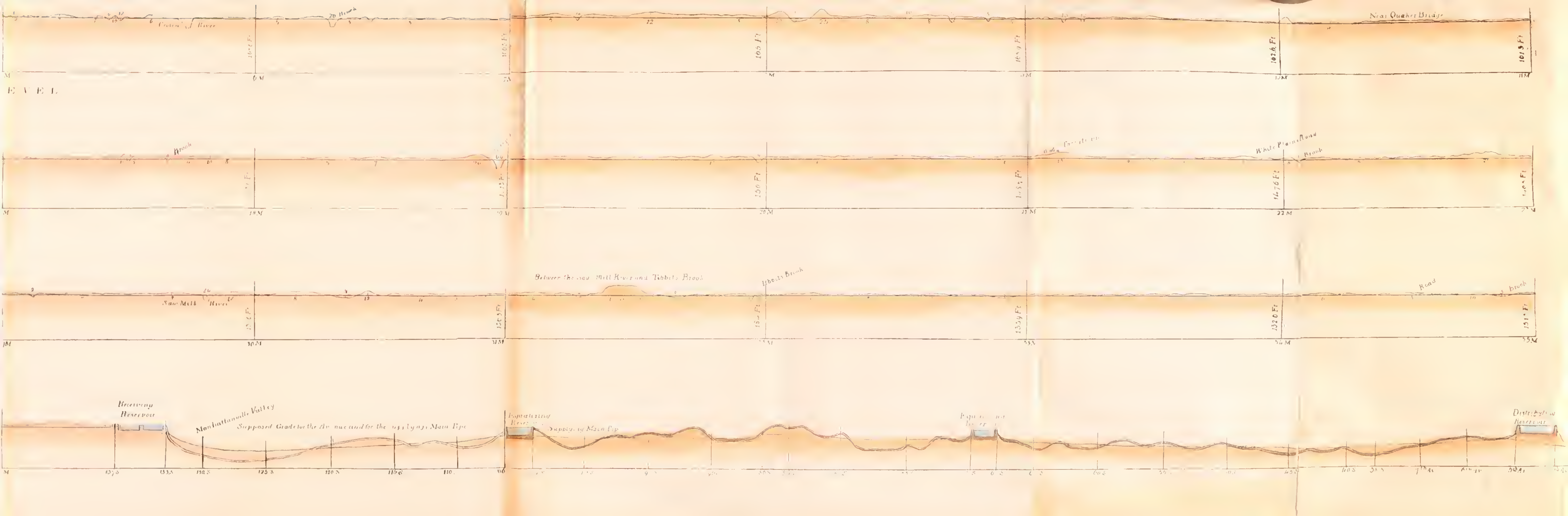
† Nos. 1 and 2, from the branches of the upper Croton.

‡ From the Croton, at Wood's bridge, at high water.


Map
of the
WATER REGION
of the
COUNTIES OF WESTCHESTER AND PUTNAM,
EXHIBITING
the vsrious lines of
AQUEDUCT
FOR SUPPLYING THE CITY OF NEW YORK
with pure & wholesome
WATER.
HUDSON RIVER
THE PALISADES
TAPPAN BAY
CROTON BAY
BUTTERMILK HILL
VALENTINES HILL
BRONX RIVER
BROOKLYN
WILLIAMSBURG
GREENSBURG CHURCH
Remark
Scale of Chains

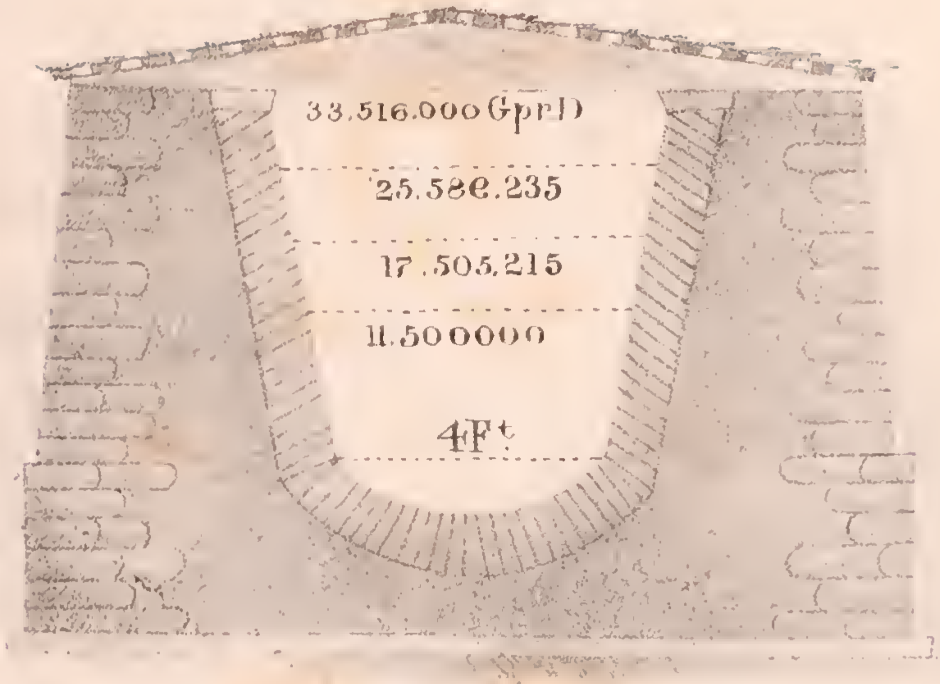


Upper Croton Water
Lower Croton Water
INTERIOR R
General Continent Reservoir
Near Wood Bridge
Brook
Road
TIDE LEV
Unionville
Brook
Road
250 Ft
9 M
10 M
11 M
12 M
13 M
Near Howlands Mill
Road
Down the Saw Mill River near Prospect Hill
Valley of Saw Mill River
192 Ft
170 Ft
21 M
22 M
23 M
24 M
25 M
26 M
Fordham Church
Brook
Brook



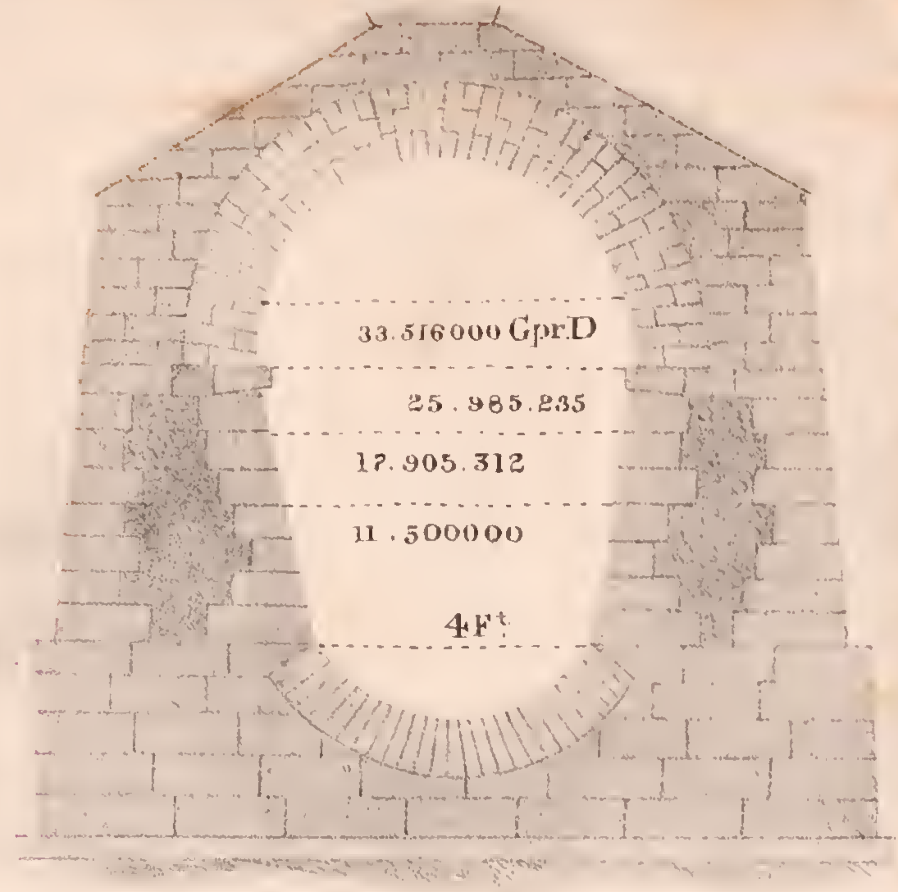
Croton River
Brook
Near Quaker Bridge
105 Ft
102.6 Ft
101.9 Ft
E V E L
Brook
White Plains Road
Brook
130 Ft
147.6 Ft
18 M
20 M
21 M
22 M
Between the Saw Mill River and Tibbits Brook
Tibbits Brook
Saw Mill River
Road
Brook
132.0 Ft
30 M
31 M
34 M
Receiving Reservoir
Manhattanville Valley
Supposed Grade for the Avenue and for the Main Pipe
Equalizing Reservoir
Supplying Main Pipe
Distributing Reservoir

Ordinary Cutting



1.

Deep Cutting



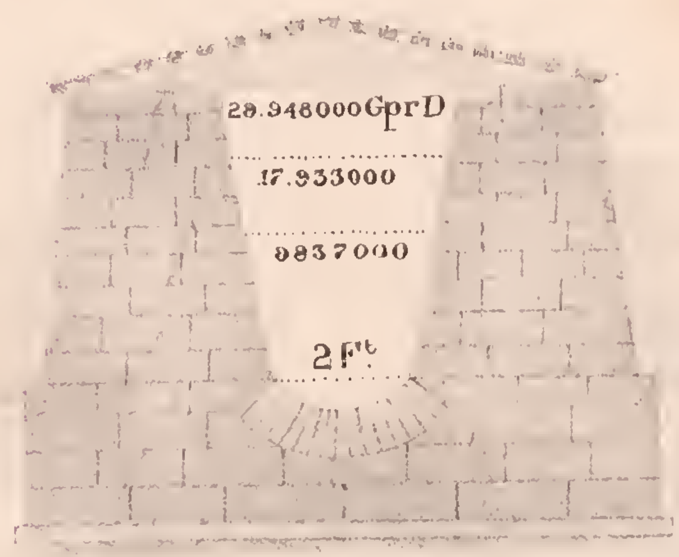
2.

Profiles of the Aqueduct on the Hudson River Route

Deep Cutting

4

Ordinary Cutting



3

Section of the Aqueduct on the Inland Route from the head of Saw Mill River to the City

Transverse Section of the Streams Guaged in the Relation of their Respective quantities of Water Guaged on the 4th 5th 6th Sepr 1833.